# ENGINEERING NEWS

AND

## AMERICAN RAILWAY JOURNAL.

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EXTENSIVE HARBOR WORKS are to be undertaken at the port of Montevideo, Uruguay. The works will comprise breakwaters to form a protected harbor, with quays and piers for shipping, as well as dry docks, landing places, and other accessories. A considerable amount of dredging will also be required, giving a depth of about 25 ft. of water. The breakwaters will be of rubble stone and stone blocks, faced on the outer side by large blocks thrown irregularly on the slope. The top will be of concrete blocks carrying a shelter wall. The shore will be protected by a footwall of stone and by slope paving. The piers and quays will be faced with concrete blocks, backed by rubble filling and earth. In some places the foundations for this work will have to be built under the compressed air system. The two main arms of the breakwater will be about 3,800 ft. and 2,600 ft. long, and the other portions will be about 2,000 and 2,200 ft. long. The piers will be 1,500 ft. long and 300 ft. wide. The total cost is estimated as follows: Breakwaters, $4,000,000; quays and piers, $3,700,000; dredging and removing rock, $2,500,000; paving, $600,000; various works, $1,140,000; total, $12,000,000. The metric system of dimensions, etc., will be used exclusively. A copy of the general plans and specifications is on file in the Bureau of Foreign Commerce, Department of State, Washington, D. C. Proposals will be received until July 31 by the Minister of Public Works.

CIVIL SERVICE EXAMINATION for structural iron designers in the Department of Public Works, and for mechanical engineers, will be held in the City Hall, Chicago, on July 23 and 24, respectively. Applications must be made at least four days before the date of each examination. Further particulars may be obtained from T. J. Corcoran, Secretary, Civil Service Commission, Chicago, Ill.

TRACK ELEVATION is proposed at Troy, N. Y., in connection with the building of a new union station, but there seems to be great difficulty in harmonizing the various interests affected. The present station is not long enough to accommodate the trains, but cannot be lengthened on account of the streets at each end. The New York Central R. R. has prepared plans for elevating the tracks, but these are not satisfactory to all concerned, and, in fact, it has been proposed to select a new site for the new station, which would necessitate an entirely different construction.

THE COMMERCIAL INFLUENCE OF RAILWAYS upon the foreign trade of China, in the section where the present disturbances are in progress, is discussed in the annual report of the imperial customs service of that country, just received by the U. S. Treasury Bureau of Statistics. This report states that the foreign trade of China during the year 1899 was characterized by an astonishing development, and merchants, both foreign and native, made handsome profits in almost every branch. The political situation, although still unsettled, gave rise to no immediate fears; exchange remained remarkably steady; the rice crop was abundant; the spring weather during the critical period for the silkworms was unusually favorable; and except for a renewal of piracy on the West River, there were no disturbances to check the trade. The gratifying result was that the year beat all previous records and showed an advance without precedent. The total trade was valued at $336,190,000, an increase of $67,000,000 over 1898, and more than double the figures for 1890. The internal trade of the country was also unusually brisk, and the important changes which will be brought about by the extension of railways have already been proved. Newchwang and Tientsin have promptly responded to the stimulus of better means of communication, and the trade at these ports has advanced rapidly, although the former suffered from a severe outbreak of the plague. It is found that immediately trains begin to run districts through which there was comparatively little traffic, such as between Paoting and Peking, suddenly commenced to show life and activity, and there springs up a flourishing trade which was formerly undreamt of and impossible for want of cheap transport. The Russian line has been completed as far north as Moukden, and the extraordinary richness of Manchuria will soon become evident. The Lu-Han Railway, from Pekin to Hankow, makes steady progress. Within six months it is expected that trains will be running as far south as Chingting.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred at Harrisburg, Pa., on the line of the Philadelphia & Reading Ry. on June 28. A switching engine pulling a train of freight-cars ran into an open switch, killing one man and injuring two.

A GREAT FIRE which occurred on the water front at Hoboken, N. J., on June 30, was one of the most terrible disasters that have ever occurred in the neighborhood of New York. About 4 p. m. some of the cotton stored on the piers of the North German Lloyds Steamship Line caught fire, and the fire spread with such rapidity that the three piers and four Atlantic liners were in flames almost before an alarm could be given. A quantity of whiskey in barrels was also on the pier and added fuel to the flames. One steamer, the "Kaiser Wilhelm der Grosse," was towed out and the flames were extinguished before any great harm had been done. The "Main" was burned at the pier. The "Saale" and "Bremen" broke loose and drifted out into the river, the former being sunk on the flats near Ellis Island, while the latter was eventually got in tow and taken upstream. The docks and the Campbell warehouses were totally destroyed, and the three steamers are expected to be a total loss. The most terrible feature of the fire, however, was the appalling loss of life, which is variously estimated at from 250 to 450 persons. The crews, longshoremen, visitors, and others were unable to escape from the ships and piers, and many were burned and drowned. Men at work in the engine rooms, coal bunkers and cargo holds of the steamers were imprisoned by the burning upper works, and either burned or suffocated, the port holes being too small to afford any chance of escape. Besides the steamers, several barges loaded with inflammable material caught fire and drifted down the river, endangering the docks and shipping. The property loss is estimated at about $6,000,000. The actual number of lives lost cannot be known for some time, as many of the bodies on the burning steamers were cremated and destroyed.

THE BURSTING OF THE RESERVOIR of the city water-works of Grand Rapids, Mich., on July 2, caused damages to property which are estimated as amounting to nearly $1,000,000. The reservoir covered an area of four acres and had a capacity of 6,000,000 gallons. At the time of the accident the water is said to have been about 20 ft. deep. The accident occurred soon after 5 a. m. A newspaper carrier saw a small stream of water coming through near the gate house and he gave the alarm, but in a very short time a break occurred in the bank. A few persons were injured, but only one seriously. According to the "Manual of American Water-Works," the distributing reservoir was 196 ft. diameter at the bottom, 271 ft. at the top, 25 ft. deep, with the flow-line 177 ft. above low water in the river. It was built partly in excavation and partly in embankment, the bank being of sand and gravel on 3 ft. of puddle, with a puddle heart wall 8 ft. thick at the bottom and 5 ft. at the top, which is 3 ft. below the top of the bank. The bank is 12 ft. high and 12 ft. wide on top. The inner slope is 1½ to 1, paved with 12 ins. of cobblestones on 17 ins. of concrete, except that the upper 2 ft. of the slope has 6 ins. of stone laid on gravel. The outer slope is 2 to 1 and is unpaved. The bottom of the reservoir is paved with 8 ins. of cobblestone on 8 ins. of concrete. The 16-in. force main and 20-in. effluent pipe are carried under the bank and have their joints enclosed in masonry piers. The reservoir was built in 1874-75 at a cost of $54,666. We expect to give full particulars of the accident in our next issue.

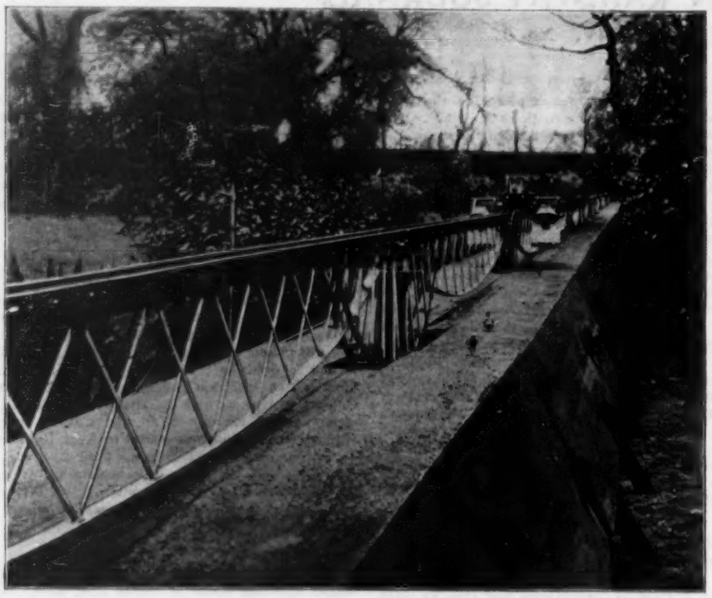
THE 600-HP. GAS ENGINE at the works of the John Cockerill Co., Seraing, Belgium, has recently been tested with excellent results. This is a four-cycle engine, supplied with gas directly from the blast furnaces in the Bessemer mill. The gas passes through dust chambers and then into a cast-iron box, where it is mixed with steam, in order to cool it and increase its density. Calculations showed that the indicated thermal efficiency of the engine rose as high as 27.10%, and that the net efficiency varied between 19.86 and 22%. The mechanical efficiency of the machine varied between 73 and 81%. On an average of the total heat supplied 20% was converted into work, 52% passed away in circulating water and 20% in the exhaust. The consumption of gas was about 31 cubic meters per HP. hour. The engine is used to supply blast to the furnaces.

A CABLE CONVEYOR FOR SLAG is being used at the copper smelting works at Dollar Bay, Mich., operated by the Lake Superior Smelting Co. The conveyor is about 600 ft. long, and the slag is dumped into a swamp, the position of the conveyor being shifted as desired. The four towers are 23 to 28 ft. high, built of 60-lb. T rails with sills resting directly upon the ground, no foundations being built, as the towers have to be frequently shifted. The slag pots, of 300 lbs. capacity, are carried out by trolleys running on a 1¼-in. endless rope, and are automatically tripped and dumped at the end of the line. Two men will operate the conveyor, while formerly five men were required to carry away the slag pots on hand trucks.

CARBORUNDUM, or carbide of silicon, may be used with great advantage in iron founding, according to F. J. Tone in the "Journal of the American Foundrymen's Association." It furnishes a ready source of silicon and carbon, and is now largely used by manufacturers of steel castings. The same properties which make it valuable to the steel maker render it even more valuable to the founder. An average analysis of commercial carbide of silicon is as follows: Silicon, 62%; carbon, 35%; iron, 1.5%; aluminum, 1.5%. Calcium and magnesium are also present in minute traces in combination with the carbon as carbides. It is well established that an increase of silicon will change combined carbon into the graphitic form, and thus give an increased softness very desirable in machine work. Silicon is a softener and lessener of shrinkage only by reason of its influence on carbon. The carbide thus becomes an ideal material for supplying any deficiencies which may exist in the original iron. Silicon is, further, a very active deoxidizing and reducing agent, and when used with "dirty" irons, containing much rust or burnt iron, it has the power of reducing these oxides to metallic iron and silica. At the same time it unites with a certain portion to form a fluid slag of iron silicates, preventing their appearance in the casting in the form of dissolved iron oxide, dirt and spongy metal. It has been found possible to melt a charge composed entirely of burnt or small, rusty scrap, and by the judicious use of the carbide, obtain a clean-flowing metal and a sharp, solid casting. It has been found that an amount of the carbide in the charge as low as 1% of the weight of the iron will have a marked influence on the quality of the castings and the behavior of the metal The method of handling carbide of silicon in the cupola is very simple. The steel founder adds the powdered carbide in the ladle as he is tapping the furnace. The heat is very intense and the carbide becomes well intermixed under the stream of molten metal, being completely dissolved by the time the ladle is filled. This method may be used in cupola practice when the temperature is sufficiently high. With the lower temperatures generally employed, however, which are 400° or 500° below that of molten steel, it is found that solution proceeds very slowly. The method most successfully employed is to charge the carbide of silicon in lump or brick form along with the pig or coke, placing the proper amount on the top of each coke charge, so that as the iron melts it will flow over the carbide.

## THE HALFORD GRADIENT RAILWAY.

In our issue of April 5, 1900, we illustrated and described the "mono-rail suspended railway," invented by Herr Eugene Langen, of Cologne, Germany. Since this curious structure was described our attention has been directed with considerable insistency to an English rival for public attention in the line of freak railway systems, which,



A MODEL OF A SECTION OF HALFORD "GRADIENT" RAILWAY LINE.

while it does not perhaps afford so good an opportunity for picturesque illustration, is in many respects quite as remarkable as a railway as is its German contemporary. This English railway is the invention of Mr. Halford, a solicitor, of Barnes, Surrey, England, and it is designated as a "gradient" railway, for the reason that it uses no other power than that provided by gravity, and is capable of imparting a speed of "200 miles per hour" to the cars which run upon it. In order that we may not seem to class Mr. Halford's invention as less remarkable as a railway than that of Herr Langen, we reproduce a view of the model line established in the inventor's garden, and abstract the following description of it from a circular issued by Mr. Halford and from descriptions which have appeared in the columns of some of our English contemporaries.

Briefly described, the track is laid upon girders, of any feasible length; each girder connected to its neighbor by a short auxiliary girder, and supported at the point of junction upon the plunger of a ram, operated by hydraulic or other power. The purpose of this ram is to lift the two girders sufficiently to give a decided down grade to the girder upon which the car is running. The operation of communicating motion to the car is described as follows: Pressure is admitted under the end support, and the ram in that support is at once lifted a distance sufficient to give a grade of 1 in 60, in the model.

The car runs down this grade by gravity; but as the front of the car reaches a point a short distance back of the second support it depresses a lever which automatically admits pressure under the ram in this second column. The ram begins to rise at once but does not attain its full height until the car has passed onto the second girder. This operation is repeated at each support and the speed of the car increases as each section is passed, and it is upon this acceleration in speed that Mr. Halford depends for his estimated "200 miles per hour." This acceleration was measured by the editor of "The Automotor," and the time of passing each of the 25 ft. girders used in the model was found to be: 8, 6, 4.2, 3.2, 2.4 and 2 seconds.

The admission of pressure to the rams, both before and behind the car, is controlled from the car itself. As a result, the gradient can be reversed and the car run back on the same track; or the track can be brought to a level and by the use of powerful brakes the car can be stopped. It should also be remarked that the ram in the rear of the car does not begin to fall until the car has left that girder.

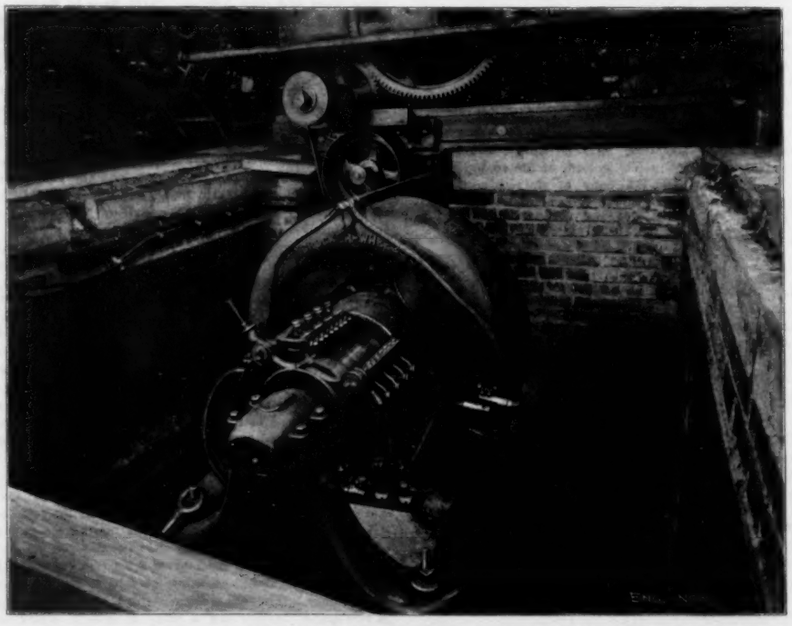
To maintain safely the great speed deemed possible the inventor suspends his two cars from a central truck, to bring the center of gravity below the rails. In the model, and at full speed, the car is said to follow an almost horizontal plane; without the undulatory motion that would be expected.

In conclusion it may be noted that Mr. Halford speaks of girders 1,320 ft., or one-quarter of a mile long, to be used in actual practice. He, however, somewhat curiously makes no estimate of cost of construction and operation and wisely confines his "advantages" to "speed, safety, and no boilers to explode."

## ELECTRICAL EQUIPMENT OF THE PRINTING PLANT OF THE ST. LOUIS "REPUBLIC."

When the proprietors of the "Republic" in St. Louis, Mo., decided to erect the present building and its plant, the electrical driving of printing presses was a demonstrated success, but there was opportunity for improvement in existing methods of speed control, and in the application of motors to the auxiliary machinery, while the question of whether or not to install an isolated generating plant had to be carefully considered from all the standpoints of first cost, economy in operation and reliability. To decide the question of the generating plant, a load diagram was plotted which showed the extent and peculiarities of the estimated demand for electrical energy for both light and power. The "Republic" is a morning paper, and this preliminary study of the conditions showed that the bulk of the power used would be between the hours of 5 p. m. and 5 a. m., the peak of the load coming during the two hours following midnight. Very little power is used during the day. This load, therefore, is a very desirable one for a central station, and the bids received from the competitors for this business were so low that it was decided that an isolated generating plant would not be a good investment.

Power is taken from the Imperial Electric Light, Heat & Power Co.'s central station (Eng. News, Jan. 18), which distributes a direct current over a three-wire system having a potential of 470 volts across its outside wires with a grounded neutral. The current passes into the building through a switchboard provided with a separate switch for each of the nine circuits which supply the different classes of service. From the switchboard each circuit passes through two Thomson wattmeters in series (one for the supply company and the other for the "Republic"), each acting as a check on the other. The nine separately measured circuits control the electrical energy used for lighting the halls, the third floor, the basement, and the counting room, and the power furnished to the passenger elevators, the freight elevators, the linotype machines, the stereotype department and the presses. The separate wattmeters furnish a ready means of checking the cost of power used by each department, and of suggesting economical measures. The only power equipment about the building is a boiler used for heating purposes, and attended to by the janitor.



GEARED MOTOR FOR DRIVING PRINTING PRESS OF THE ST. LOUIS "REPUBLIC."

In connection with the motor equipment, the application and the speed control of the press motors was the most serious problem. The print-

ing of the "Republic" requires three Hoe quadruple presses, each capable of printing 24,000 papers per hour. The main driving shaft of the press turns 200 times a minute when the press is running at its highest speed, and this would be the maximum speed of a direct-connected motor. This slow speed would result in a large motor, and its application directly to the shaft would locate it in an inconvenient place. The motor was, therefore, geared to the shaft so as to bring the maximum motor speed up to 700 revolutions, and by means of a train of gears it became possible to place the motor beneath the floor at the side of the press.

The four-pole motor is illustrated in the accompanying cut, which indicates the construction adopted and shows the steel lined brick pit provided to secure a water-tight compartment for it. The press room floor is composed of cement, except over the motor pits, which are spanned by hard-wood planks, which arrangement secures easy access to the motor and connections. A small manhole is placed at one side of the pit for the ordinary purposes of oiling and inspection.

The method of speed control adopted is a combination of armature resistance, field regulation, and the "teaser" system. In operating newspaper presses it is essential to provide five or six very slow speeds to be used in adjusting the presses, and in threading through the paper while "making ready" to run an edition. In doing this work, the press attendants become familiar with certain speeds, and any variation not only hinders them in their work, but is also liable to prove dangerous to the hands which are trained to certain motions. These slow speeds must, therefore, be constant.

The limitations to the use of resistance in series with the armature for securing a reliable slow speed from a motor working on a variable load are well known, and its use was not considered in connection with this plant. The very slow speeds are secured by the use of a "teaser," which is a small motor-driven dynamo running at a constant speed. The motor end of this teaser takes its current directly from the 470-volt mains, while the generator end delivers current to the press motor at a potential varying between zero and 80 volts. Additional slow speeds are secured by cutting out resistance in the press motor armature circuit, and for higher speeds the press motor is thrown directly upon the 470-volt mains.

The various combinations and the resulting speeds are secured by the manipulation of a controller located at the side of the press. It is very much like a street car controller, and is provided with a hand wheel fitted with a pointer which moves over a dial containing 21 points. The controller is placed on the first point, which admits current to the press motor from the teaser generator, and results in the lowest running speed. The speed is increased by moving the controller from point to point—a ratchet and spring device preventing the stopping of the controller handle between the points. Six different slow speeds are secured by means of a teaser. When the controller handle passes to point (7) the teaser is cut off from the press motor, and the motor begins to get its current from the main line through resistance. Points (7) to (10) are running points, using armature resistance in the motor circuit, the resulting number of impressions being from 8,000 to 20,000 per hour. When the controllers reach point (11) all the armature resistance is taken out of the circuit and the motor is running most efficiently with its strongest field, and the press is printing about 22,000 papers per hour. The higher points on the controller introduce resistance in the shunt winding, thus weakening the field and speeding up the motor. These higher speeds are seldom used.

The controller is provided with a solenoid circuit breaker. The underload feature of this circuit breaker can be operated from any one of six push buttons distributed at convenient points about the press frame. A band brake, actuated by means of a spring and controlled by a solenoid magnet in series with the main circuit is provided, which applies itself instantaneously to gradually stop the press in case the line circuit fails or any of the stop buttons are pushed in cases of emergency. Each press has a 40-HP. motor, though the actual power required at present is less than 30 HP., the extra capacity having been provided for driving another "deck" to be added to the press in future.

The leads to each motor are controlled by a switch on the press, and are also protected, in addition to the automatic devices on the press controller, by means of an overload circuit breaker on the press frame, convenient to the operator. A carbon resistance is connected across the terminals of auxiliary clips on the main line switch in such a way as to take up the field discharge when the switch is opened. The armature and field resistance are mounted on a frame placed beneath the press, and both are arranged in sections so that their subdivisions can be changed and any desired arrangement of speeds can thus be secured. All the wiring between the motor, the controller and the push buttons is done in iron armored conduits.

There are 20 Mergenthaler linotype machines, each operated by a motor of ¼-HP., driving the main shaft by means of a worm gear. In the illustrating department a ½-HP. motor is used to operate the rocking device of the acid bath, another ½-HP. motor is belted to the routing machine, and a 2½-HP. motor is belted to the saw and trimmer. In the stereotyping department, a 2½-HP. compound wound motor, running at 450 revolutions, operates the matrix rolling machine, which has a reversing table. The motor is provided with a long pulley and an outboard bearing. From the pulley the belt passes to the driving pulleys under two idler pulleys, which are carried on a special bracket and can travel along their shafts when the belt is shifted. The machine for cutting and trimming the stereotype plates is driven by a 4-HP. compound wound motor supported on a bracket and attached directly to the saw shaft, which runs at 1,400 revolutions per minute. The machine for shaping the curved interior surface of the plates is driven by a similar motor running at 900 revolutions, and geared to the driving shaft by a rawhide pinion. It is necessary to have the shaving knife make one revolution and then stop in a position which will allow the insertion of the next plate. This is accomplished by a push button device which short-circuits the magnet in the automatic starting box, thus stopping the motor.

Other motors are used to operate a freight elevator, three paper carriers, a form elevator, a paper lift, and two passenger elevators. The pneumatic tube system is operated by a centrifugal fan driven by a 5-HP. shunt wound belted motor, with an automatic resistance speed controller. The building is lighted by 235-volt incandescent lamps, and by arc lamps run two in series across the 235-volt main. The 220-volt arc lamps were found to be unsatisfactory for interior lighting, on account of the preponderance of violet rays.

Mr. Bion J. Arnold, of Chicago, was the consulting electrical engineer, and the entire motor equipment was furnished and installed by the Crocker-Wheeler Electric Co., of Ampere, N. J. Mr. Charles W. Knapp is President of the "Republic," Mr. W. B. Carr is Business Manager, and Mr. Isaac Taylor was Architect for the new building.

## RAPID RE-ERECTION OF THE KANSAS CITY CONVENTION HALL.

The destruction of the Convention Hall at Kansas City, Mo., by fire, on April 4, occurred just after this had been selected as the place of meeting for the National Democratic Convention on July 4, and it became necessary to exercise the most urgent haste in the reconstruction if the building was to be ready for the use of the convention. The building, as described and illustrated in our issue of Nov. 2, 1899, was 314 × 198¼ ft., with seating accommodation for about 25,000 people. The walls were of brick and stone, supporting steel roof trusses of 187 ft. 4 ins. span, c. to c. of end pins, and 32 ft. 6 ins. deep at the center, spaced 23 ft. 6½ ins. apart. These were connected up in pairs by lateral bracing. The roof was of planking, covered with tar and gravel. The wreck was complete, the great trusses falling to the floor and being broken, bent and twisted by the fall and by the intense heat to which they were subjected. In fact, we are informed that in one case a piece of a cast-iron bracket became welded firmly to the web of an I-beam. The removal of such a wreck was a matter of no little difficulty.

The building was destroyed April 4, as noted in our issue of April 12. On April 7, the proposal of the Gillette-Herzog Mfg. Co., of Minneapolis, Minn., for reconstruction, was accepted, this firm having built the original structure. The final contract was closed April 9, putting the contractors under heavy penalty to have the work completed by June 15, this being considered the latest date which would allow time enough to get the building covered in and finished for the convention to be held on July 4. As the contractors' shops were already running night and day on other rush orders, arrangements were made with the Carnegie Steel Co. to build part of the work at its Keystone shops, from the drawings of the Gillette-Herzog Mfg. Co. This covered about 368 tons, which was all that the Carnegie Steel Co. considered it would be able to finish in time, getting the material rolled at the mills. The remainder of the work, amounting to about 240 tons, was manufactured from the large stock of material carried by the contractors at their Minneapolis works.

On May 1, the ground had been cleared, the masonry was being rebuilt, and the movable falsework erected. This falsework sufficed for the erection of each pair of trusses, and had one end of its platform extended beyond the building, over the street, with a derrick by means of which material was hoisted up. Upon the falsework was a traveler for the erection of the steel work. The first pair of trusses was swung on May 7; the second pair on May 12, and the fifth and last pair on May 27. This made a record of 47 days for the partial manufacture, the delivery and the erection of about 600 tons of steel at a point remote from rolling mills and shops. Fast through freight service was arranged over the Pennsylvania Lines and the Chicago, Milwaukee & St. Paul Ry.; the last of the material being delivered in Kansas City on May 9. The time of transit for material from Pittsburg to Kansas City ranged from three to five days.

The original designs were not followed entirely, but changes were made as noted below. The supporting column shafts were changed from 10-in. Z-columns (⅝-in. metal), to three 10-in. I-beams, riveted together; bracing angles were slightly increased so as to allow the use of stock material; 6-in. and 7-in. channel sections in the trusses were changed to 8-in. chanels and rolled; all 9-in. channel sections were changed to 10-in. channels, of which there were but few, and could be cut from stock; the 10-in. channel web members were changed to 12-in. and rolled. The different sizes of angles in the trusses were limited to 3 × 3 ins., 3 × 4 ins. ,and 6 × 4 ins.; lugs and short pieces of other sizes being sheared from these, or cut from stock. The lower gallery construction was modified considerably, the new gallery being inclined while the old gallery was horizontal.

## THE PRESENT STATUS OF RAILWAY DEVELOPMENT IN CHINA.

In the May number of the "Revue Generale des Chemins de Fer," Mr. M. G. Bouillard prints a map showing the various railway lines in operation, under construction and projected in China, and discusses briefly the present status of each project. In view of the attention just now being directed toward Chinese affairs, and particularly toward the development of that country's resources by railway construction, we have redrawn Mr. Bouillard's map in a more intelligible manner, and abstract the following facts of principal interest from his description of the several schemes.

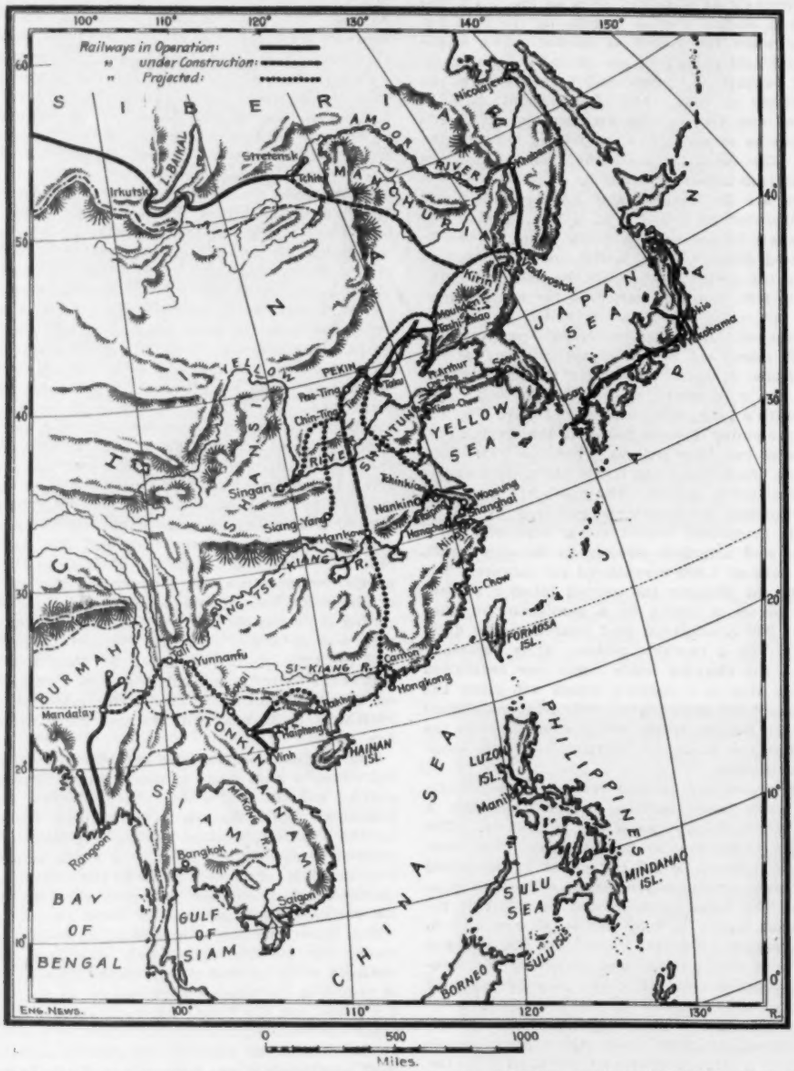
The first railway constructed in China was a short line, built in 1876, to connect Shanghai with Woosung. This line, 11 miles long, was built and operated by an English company; but it was later destroyed by order of the Chinese government, and the rails were taken to Formosa. While the de

struction of this road is charged to popular dislike of railways, the people in this case were only the agents of the mandarin class, which feared that the foreign element was obtaining too much power, and would eventually interfere with Chinese affairs and their own schemes.

The northern railways of China had their origin in the exploitation of the coal mines of Kai-Ping, east of Pekin, and operated since 1885. The commercial direction of these mines was in the hands of the Chinese; but an English engineer, Claude W. Kinder, M. Am. Soc. C. E., and now Engineer-in-Chief of the Imperial Railways of China, had charge of the actual working of the mines. At first, the coal was hauled to Hsu-ko-Chuang on a little tramway, about eleven miles long, and then carried to Tientsin by water. The trouble with this arrangement was that in winter, when business should have been most active, the river was frozen up and transport was impossible. After much cautious work on the part of Mr. Kinder, in overcoming the Chinese prejudice against railways, and by indomitable perseverance, a line was finally built to Tientsin and to Taku, on the Gulf of Petchili. This railway was exclusively Chinese, in capital and in direction, and the line was further extended to the northeast of Kai-Ping, to reach the new collieries opened at Ku-Yeh.

In 1892, Li-Hung-Chang, then Viceroy of Petchili, and one of the founders of the Chinese Engineering & Mining Co., which operated the coal mines and the railway, decided to extend the road to Shan-Hai-Kouan, upon the coast, north of Taku. In 1895, after the Chinese-Japanese war, the Chinese government bought from the above company the railway between Ku-Yeh and Tientsin; and the English engineers, now at the head of the Imperial Chinese Railway, prolonged the line from Shan-Hai-Kouan towards Neu-Chang and Kin-Chou. The Imperial Railway then included the Pekin-Tientsin line as well as that extending from Tientsin to Shan-Hai-Kouan. This line was considered as of considerable importance to the English, who were the masters of the Lower Yangtze, and by building a railway to Hankow, would hold the only line leading from China to Europe. But the Russians intervened, with a proposition to build railways north of the Great Wall, just as the Hong Kong & Shanghai Banking Co. obtained a concession for the line wanted by the English. This English bank had engaged to raise about $11,000,000, at 5%, to prolong the line from Pekin to Chan-Hai-Kouan, and then to Neu-Chang. As a guarantee it was to control the revenues of the Pekin-Tientsin and Chan-Hai-Kouan lines, and the extensions of these lines; and the engineers were to be Europeans. But the Russians brought it about that the control should remain with the Chinese, and the Hong Kong Bank was forbidden to hypothecate the road. Finally, Russia and England came to an agreement and divided up their spheres of influence in regard to railway construction; and England withdrew its claims upon the revenues of the railways to Chan-Hai-Kouan.

Mr. Kinder directed the work which followed.




SKETCH MAP SHOWING RAILWAY LINES COMPLETED, UNDER CONSTRUCTION AND PROJECTED IN CHINA.

After the war of 1895, and after much angry discussion between the old and the progressive party of China, the line to Pekin was stopped within 1.8 miles of the South Gate of that city, at Machiapu; and since July 1, 1899, this gate has been connected with the railway by an electric tramway, built by Siemens & Halske, of Berlin. This tramway was a great curiosity to the Chinese; but it is little used, as it ends outside of the Chinese city, and far from the commercial center. It is said that Mr. Kinder has been endeavoring to have it extended beyond Machiapu towards Tong-chow, which is an important commercial town.

The Shanghai-Woosung railway has been rebuilt by German engineers, and was opened in 1898, under a Chinese company, at the head of which is S. E. Sheng, one of the boldest and most enterprising men in China. This road is eventually to be extended to Soutcheou, Tchinkiang and Nankin, under a concession granted to Jardine Matheson & Co., an English firm, of Shanghai.

Among the lines under construction, the most important is the Pekin-Hankow Railway, which is to form the great trunk of the system of the Imperial Company of Chinese Railways, under Director-General Sheng. A Franco-Belgian syndicate obtained the concession for the construction of this line, on June 26, 1898. A previous company, under a concession granted Oct. 20, 1896, had built the line connecting Pekin with Poa-Ting-Fou, under English engineers. The Franco-Belgian syndicate is authorized to issue $22,500,000 at 5% to build the railway from Poa-Ting-Fou to Hankow, under a concession for 30 years; besides the guarantee of the Chinese government in case the road costs more, the latter agrees to devote the receipts of operation to the payment of interest and a sinking fund which is to extinguish the capital in 20 years. About $12,400,000 of this capital has already been subscribed for in France and Belgium, notwithstanding rumors effecting the safety of the investment. With the railway finished, its commercial and technical operation will be in the hands of the Franco-Belgian Company. The traffic on the Pekin-Poa-Ting-Fou line, now in operation, is said to be already very important. The construction company is at work at the two ends, and from Poa-Ting-Fou to Chinting-Fou, about 74.4 miles, the earthwork is almost completed and the rails are being laid down. At the south, between Hankow and Syniang, 155 miles, the work is progressing rapidly.

The Manchurian Railway commences at Tschita, on the Trans-Siberian line; it then crosses the mountains of Argan and Hingan, and reaches Kirin, where it branches to Nikolskoie, on the Vladivostock-Khabarovsk line. The total length of this railway is about 1,426 miles, of which 992 miles are in Chinese territory. This concession dates from 1896; but in 1898 Russia forced permission for the construction of a railway leading from Kirin to Port Arthur and Talienwan. The length of this extension is about 403 miles; and from a commercial point of view it will be the most profitable of the Manchurian lines.

The Shansi railway, conceded to a Russian-Chinese bank, would be a branch of the Hankow-Pekin system. It is intended to open up the rich mineral deposits, coal and iron, in the Shansi plateau, and would reach Tai-Yuen-Fou, the capital of that province. The road would be about 124 miles, and a French syndicate expects to build it.

In the south of China and in Tonkin, France has acquired concessions to build three railways. That for the railway from Laokai, on the north boundary of Tonkin, to Yunnan-Fou, was obtained in 1896. It would be about 157 miles long, and is to be built from the Indo-Chinese bond issue of $40,000,000. Another line would leave Tonkin at Namquan, and be eventually extended to Nanning, about 100 miles. The Company Five-Lille has obtained a concession from the Chinese government to build this line, with a capital of $2,700,000, at 7%, to be floated by the Chinese government in France. The last line is one to connect Nanning with Pa Khoi, which has been ceded to the French government in compensation for the murder of Father Berthollet.

An English-German syndicate, represented by the Hong Kong-Shanghai Bank, has secured a concession to build a railway from the Tientsin line south to Tchin-Kiang, a distance of about 620 miles. This line would compete for business with the Pekin-Hankow line, and also reach the northern system of Chinese railways; as a consequence the Franco-Belgian interest is strongly opposed to it.

Across Shantung Province the Germans have obtained a concession to build a railway, about 434 miles long, between the coast, at Kiao-Chiau to Tsinan, on the English-German line before mentioned.

An English-Italian syndicate has obtained concessions controlling the mineral deposits of Shansi and Shensi; and this syndicate is also authorized to build the railways necessary for the exploitation of these mines, and bring them out to centers of distribution. Jardine Matheson & Co., an English company, has obtained the following concessions for railways: From Shanghai to Nankin, by way of Sou-Chou, 167.4 miles; from Sou-Chou to Hong-Kow, about 223 miles; and from Kow-lun, the newly-acquired English territory opposite Hong Kong, to Canton, about 100 miles.

The proposed Hankow-Canton line is under the concession of an English-American syndicate. It would form part of the system of Imperial Company of Chinese Railways controlled by Director General Sheng. As this line is the natural prolongation of the Hankow-Pekin railway, the Franco-Belgian syndicate claims the right to enter upon it in case there is delay in raising the capital and commencing work.

At the Burmese border England is seeking concessions permitting her to extend her line to Kulong-Ferry, now under construction from Mandaley, to Yunnan-fou. French engineers believe that this line presents insurmountable difficulties, as it traverses a mountain region. The line would be about 744 miles long.

Since the above article was written the American minister at Pekin announces the completion of the railway connecting Tientsin with Neuchang, a distance of 348.6 miles. This is the branch of the Imperial Railway, extending towards Moukden. The Chinese Eastern Railway is also finished from Port Arthur to Moukden—both of these changes have been indicated on the map, as is also a connection lately made between the Imperial Railway and the Russian Port Arthur-Moukden line, at Ta-shi-chiao. Owing to the danger of operating railways in China at night, it will take about three days to go from Port Arthur to Pekin. The Russians expect to have their railway open from Moukden to Vladivostock by August next.

Trains are now running on the Trans-Siberian Railway as far east as Stretensk, and the schedule time is given as follows: St. Petersburg to Lake Baikal, 9 days; Lake Baikal to Strentensk, 3 days; by the Amoor River to Khabarorsk, 6 days; to Vladivostock, 1 day; total, 19 days. It is expected that the line from Tschita, across Manchuria, to Kirin will be in operation in about 18 months, and this will considerably shorten the above journey.

## RAILWAY ROLLING STOCK AT THE PARIS EXPOSITION.

That American railway practice is in advance of that of all the rest of the world is a proposition whose truth most American engineers take for granted. It is rather disappointing, therefore, to find that in this great exposition American railways and railway materials are very meagerly represented—one might almost say not represented at all. Our export of locomotives to foreign countries, especially during the past few years, has been a subject of national enthusiasm. Yet, at the present writing, among the hundred or more locomotives exhibited here there is not one typical American machine. There are, indeed, two Baldwin locomotives, one built for the French State railways, and the other for the Great Northern Ry. of England, but each of these has many foreign details, even though it is of American construction, and follows American practice in most features of its design. I am told that some Richmond locomotives are promised later; but that is the situation at present. In the freight and passenger cars the United States is not represented at all, save by some small models in the Civil Engineering exhibit. European practice in freight carriage, especially, is very different from our own, and it is in that particular department that we can most justly pride ourselves on our achievements. It would have been of great interest, therefore, to have shown here at Paris one of our standard 60,000-lb. box cars, for example; and it would have been a much studied object lesson to the thousands of European railway officers who will visit the exposition. In stock cars, refrigerator cars, hopper gondolas and other special types, too, a display could have been made that might have been worth a great amount in its influence on our export trade. There is, indeed, one American firm, the Goodwin Automatic Dumping Car Co., with an exhibit of working models in the engineering section on the Champ de Mars, and the Pressed Steel Car Co. has several cars at Havre, I understand, which are too large to pass within the clearance limits on Frecnh railways. How they are to reach the place reserved for them in the United States section at Vincennes appears in be still undetermined, and thus the Stars and Stripes are now displayed there over tracks which are largely vacant.

The meager showing which we make would be of less importance if the railway exhibit here were on the whole a "tuppenny" affair. But it isn't. On the contrary, it is surprisingly complete. The French railways, of course, take the lead; and they have locomotives enough on exhibit to stock a god sized railway system. Russia and Germany also have very extensive exhibits, and all the other European nations are well represented. In fact, besides considerable display on the Champ de Mars, there are between one and two miles of tracks in the sheds at Vincennes completely filled with cars and locomotives. Probably a better opportunity was never presented to study European practice in rolling stock, especially in locomotives and passenger cars. Freight cars are comparatively few in number.

The first thing that strikes one in looking over this display is the great diversity of design on European railways. This probably is due to the fact that national boundaries, differences of language and lack of free intercourse between the officers of different roads, has left each to evolve it's own designs to a large degree. Our own way has great advantages unquestionably; and yet as I view some of these novelties and experiments in construction, I realize that our way tends toward conservatism as well, perhaps too much so at times. It is a common idea that the American is more progressive and ready to try new ideas than the European, and that our national progress is largely due to this fact. Whether this is true or not, I would pity the man who should set out to induce an American railway company to build a locomotive like some of those shown at Vincennes. One is forced to conclude, after looking them over, that there are a whole lot of ways to build a workable locomotive, and about every detail connected with it. Possibly some of these ways may be as good as, or better, than the American way.

### Locomotive Valve Gears.

Probably the most conspicuous detail of the European locomotive, to an American eye, at least, is the outside valve gear. It looks complicated. Some of them undeniably are. Yet if all the railways on the continent of Europe so universally use the outside gear, is it not possible that there may be some advantages in it for us to consider? I presume 999 out of every 1,000 locomotives in the United States have valve gear driven by eccentrics and the familiar Stephenson link motion. Yet it must be acknowledged that eccentrics do give more or less trouble. The speed of the rubbing surfaces of the eccentrics on a fast passenger locomotive is enormous. The wonder is that they don't get hot and cut oftener than they do. The extensive use of balanced valves in the United States has somewhat eased the load on the eccentrics, and perhaps their non-use in Europe is one reason why outside valve gear has been so extensively adopted.

It is true, the outside valve gear gives a complicated and unpleasing appearance to a locomotive English locomotives never have it, so far as I am aware; and as the inside cylinder engine is the common one there, and the plate-frame hides all the interior parts, most English locomotives have hardly any moving parts in sight. Some Englishman has objected to the American locomotives "because its internal organs are so indecently displayed." If our American engines are objected to on this score, however, then some of these outside valve gear Continental engines are positively immoral.

Seriously, however, I am not at all sure that the outside valve gear may not be the coming thing after all. It ought to be possible to greatly simplify it, and by the use of balanced valves to reduce the strain on and weight of the parts. Perhaps, too, we shall yet see some revolution in the valve itself. Anyone who watches some of these big stationary engines in the European exhibit here, with their poppet valves and very simple gearing, must be impressed with their quiet and smooth working and evident merit. It looks as if the complicated Corliss gear had had its day. The small amount of power required to work poppet valves would greatly simplify the valve gear question, should such valves be applied to locomotives.

If outside valve gear ever becomes the fashion on American locomotives, however, it is safe to say it will differ greatly from some of these remarkable examples shown here. The complicated labyrinth of links and rods and levers and cranks on the sides of some of these locomotives gives one a pain, when he thinks of the labor the designers must have bestowed, and a worse one when he considers the task of computing the net counterbalance required in each driving wheel for these manifold weights moving in all sorts of directions.

The slide valve still seems to be the general favorite abroad, and is very seldom balanced. Piston valves, however, are growing in favor, especially on compound locomotives. The recent American wrinkle of a relief valve on the steam chest is seen here very seldom. Extended piston rods are quite common, and the center rod of the piston valve is also frequently extended through to a bearing in the opposite end of the cylinder in which it works.

### Compound Locomotives.

It has been said that the compound locomotive is losing its foothold in Europe; but it would not appear so from this exhibition. Roughly, there appear to be at least as many compound as simple engines shown, and there is every variety that the mind of man can conceive. There are two-cylinder, three-cylinder and four-cylinder compounds, and the cylinders are arranged in every possible way. Outside steam pipes to the cylinders are quite common, and are necessary with some of the peculiar arrangements adopted.

### Throttle Valves.

The slide valve throttle is as universal on European locomotives as the double poppet is on American. There is seldom any latch to lock it in any desired position, as it simply "stays put" wherever it is left, and does not close itself like the double poppet. The supposed advantage of our double poppet valve is that it will open more easily, but this does not appear to be realized in practice. The throttle lever of these European locomotives is much shorter and takes up less room in the cab than the American throttle lever. I believe there is a relief valve attachment to the slide valve, which is opened by the first movement of the throttle lever. This relieves the pressure, so that the remaining movement is easy. Certainly the starts made by these European trains are astonishingly smooth. One trouble with the American throttle is that it opens so hard at the start that the engineer pulls it too wide open, jerks his train under way, slips his drivers, tears his fire, and makes a big noise generally.

### Reversing Gear.

Another typical difference in European and American locomotives is the reverse gear. The latter always have a lever. On European engines the screw gear is universal, even on small engines. An objection which may be raised to the screw gear is that it is impossible to "throw her over"

quickly in case it is necessary to make a sudden stop. That would have been a sound objection before the days of driver brakes; but it hardly holds good now. The way to stop a train in the shortest distance is to shut off steam, apply brakes and let the reverse lever alone. With this objection disposed of, I see no reason why the screw reverse gear is not a better device than our lever gear, especially on heavy locomotives, where it is now very hard to remove the reverse lever, and often it cannot be adjusted when the engine is using steam. Besides this, with the screw gear, the cut-off can be adjusted at any time, and can be fixed at any point. One objection raised to our reverse lever and notched quadrant, is that the notches are not close enough together to suit all conditions. In fact, special quadrants have been devised with attachments to permit a finer adjustment of the cut-off.

### Cabs.

In the general convenience and comfort of our cabs we are very far ahead of our European friends. One wonder how men are able to live in some of these French and English cabs in times of severe storm. The German and Russian cabs approach more nearly to our own ideas of what a cab should be, but the American plan of providing comfortable seats for engineer and firemen is absolutely unknown here. The Baldwin locomotive for the French State railways has some very small seats, such as would not pass muster at all in the United States, yet they attract the notice of every visitor who came along. The exclamations and gesticulations over those seats were highly entertaining. I did not understand the language; but apparently they were saying: "They'll be giving 'em feather-beds next."

Let me set it down at once, however, that there are two wrinkles for the benefit of the firemen in European practice which are worth copying. The first of these is a lever for opening the firebox door. The spindle on which the door is attached is continued upward and a substantial lever is secured to its top. This lever swings around on an arc with notches into any of which the lever can be dropped to lock the door either wide open or at any point desired for admitting air over the fire.

The other idea relates to the tender construction. The typical American tender has a water tank shaped like a U, and the coal is placed between the legs of and on top of the U. Many of these European tenders have the water carried in a tank with a flat top extending over the whole floor of the tender. This top is given a slight incline toward the front, and all the coal is carried on this floor. In other words, the lower part of the tender is for water, the upper is for coal, and here comes in the advantage: The fireman shovels his coal off a platform waist high, instead of off the floor at his feet. There is no doubt that on our large locomotives we will have to do something to help the fireman, or else put on two men to do the firing. I think these two schemes, simple as they are, of a good deal of importance. Very likely one or both of them may be in use to some extent in the United States, but they are certainly not common practice.

Of peculiar and unusual things in cab fittings, boiler attachments, etc., there is an endless variety. As has been already remarked, American locomotives follow closely certain standard lines. Each attachment has its particular location where it may almost invariably be found. Not so on these European engines. Here the various attachments wander about anywhere. The air pump—if there is one—may be put next the cab on the right-hand side, where the American puts it, or it may find lodgment near the center of the boiler or even out on the front end. Lubricators dodge around where least expected; steam domes may be found anywhere from the cab to the stack; and I have even seen a glass water gage riding out front beside the boiler-feed check valve. Whether the engineer took a trip out there when he wanted to inspect it or used a long range telescope, I could not ascertain.

One novelty in cab fittings deserving a word of mention was found on a trunk locomotive with the rear end of the cab closed in, and consisted of a good sized ventilating hood in the roof of the cab facing toward the front, so that it took in a blast of air when the engine was running like the ventilating funnels of an ocean steamer.

### Pilots.

The American pilot or "cowcatcher" is, of course, not to be seen anywhere among the exhibits. Yet, evolution appears to be tending in that direction, curiously enough. In biological study we learn how primitive forms develop into more complex ones. Most European locomotives have what might be called a rudimentary pilot in the shape of "knives," as they are called, heavy flat bars of steel, secured to the frame and extending down toward the rail just ahead of the front truck wheel. Some of these knives have a projection toward the center of the track like a plowshear, evidently designed to throw outward any object struck by it. If evolution proceeds farther in this direction, a pilot may yet be developed on foreign locomotives.

Another way in which it may develop is from street railway practice. Some of the street cars on exhibit have small V-shaped fenders attached to the truck, and there are one or two examples of something more ambitious in the way of a fender. Still another possible lever in the same direction is the idea of reducing air resistance. The Paris & Orleans Ry. has really taken up this matter seriously, and is applying a sharp prow or "beak," covering the front end of the smokebox and extending up around the stack, to all its new fast passenger locomotives. This beak, however, extends no lower than the bottom of the boiler. If it is worth while to attempt to reduce air resistance by a shield, it is nowhere more needed than in front of the front truck, and it may yet occur to them to put a sort of "pony snow-plow" on the front of the truck, which would make a very fair pilot.

### Boilers.

European locomotives, like American, are evidently developing in the direction of greater boiler capacity, although they have not gone so far as we by any means. The firebox is still placed between the frames almost universally, although in a few cases it is placed on top. The recent American development of fireboxes spread over the wheels is not seen at all here. Lagging is almost always placed on the back of the boiler-head, and on the firebox sides. Drilling tell-tale holes in stay-bolt ends appears to be common, and the lagging, and even the frames are frequently perforated over these holes to allow steam to show in case of a broken stay-bolt.

A good deal of trouble seems to be experienced with wet steam; at least numerous devices are to be seen for increasing the steam space. The use of two domes with a large pipe connecting them is common, and one locomotive here has a large drum on top of the boiler instead of a dome. Lever safety valves on top of the dome are common, and often have their ends held down by a long spring enclosed in a brass case, with its lower end secured to the barrel of the boiler. In some cases an adjusting weight is added. The American pop valve is much neater and more compact. Hand-holes for washing off the crown sheet are frequently placed over the top corners of the firebox.

### Running Gear.

The lack of uniformity already noted is characteristic of the running gear as well. There is no such fixity of type as enables American locomotives to be classified by their wheel arrangements alone. The European locomotive has anywhere from two to twelve driving wheels, and truck wheels distributed around anywhere the designer feels like it. Both average larger in American practice; and as steel-tired wheels with cast steel or wrought centers are universal, the designer is under no limitations in this respect.

Equalizing levers are quite frequently seen, but the use of very long plate springs partially does away with the necessity for them.

A good device—which I believe has also been used to some extent in the United States—is an oiling pad for the flanges of the leading truck wheels on very heavy locomotives. It is merely a hollow rectangular metal case, about $8 \times 4 \times \frac{1}{2}$-in., filled with felt, which projects from the lower end. This is held by a clip, so that the projecting felt just touches the wheel flange.

Many of the locomotives from the roads of Northern Europe have broom-holders attached to the front truck. These are filled with birch twigs in winter, and clean the rail top of snow. One model of a large push snow plow, used on a Russian railway, has its vertical cutting edge inclined forward instead of backward, as is common in American practice, and the inside has a ballast compartment which is loaded with stone to hold the plow on the rail.

### Brakes.

There is probably no feature in which American railway practice is so distinctly in advance of the rest of the world as the matter of brakes. This is due, not alone to the genius which developed the Westinghouse brake, but to the very fortunate circumstance that that brake was pushed with so much better business ability than its rivals that they all were forced to succumb. The fact that there is only one standard railway brake in the United States to-day is worth many millions of dollars a year. Not only to the railways themselves, but to the public which they serve.

European railways still suffer from a diversity of brake systems; the Westinghouse system appears to be in the lead; yet there are enough other systems in use to make more or less trouble. This would be a more serious matter than it is except for the fact that no such general car interchange system exists as in the United States. About the only cars which cross international boundaries and go to and fro over the lines of different railways are the cars belonging to the International Sleeping Car Co.—the Pullman system of Europe. These have to be equipped, of course, with brakes of all the different systems over which they run. The same thing is done with through cars on some of the routes in England.

In general, European locomotives appear to be almost invariably equipped with lever brakes and pessenger rolling stock, with air brakes of some sort. As for freight rolling stock, its equipment with air brakes is not yet in sight. In fact, when one sees some of the curiosities in hand brake gear here, he is impressed with the idea that a uniform hand-brake equipment is needed first of all. On the other hand, it is not easy to see how hand-brakes could effectively be worked. Freight trains are not made up of box cars here with a running board the whole length. It is difficult or impossible for men to go along a European "goods" train when it is running.

Here is a sample of European ideas as to brake gear: In the French civil engineering exhibit on the Champ de Mars is a four-wheel tank car, weighing with its load 46,700 lbs., a very fair load for four wheels. The brake gear on that car consists of a rock-shaft hung to the body, and carrying the break head on a projecting arm. The brake shoe is of wood and is applied to one wheel of the car only. Keyed to the above-named rock shaft is a heavy iron lever, some 15 ft. long, reaching to the opposite end of the car and with its end resting on a projection. To apply the brake the "guard" reaches down and throws off the end of the lever and lets it fall, and he can if he likes push it down and let it catch under notches in the frame which guides its end.

This is not a freak idea either. It is a standard form of brake gear on one of the principal French railways, and they think so much of it that the methods of making the detail parts in their shops form part of one of the exhibits.

It must be freely conceded, however, that the equipment of European freight cars with air brakes is not an easy problem. There is such a diversity of types, and such a vast number of these small four-wheel cars that the investment necessary to equip them with brake gear and the expense of its maintenance are appalling.

Russia alone seems to be moving toward the adoption of American practice in a uniform brake system for all trains, and the use of freight cars of larger capacity. No one who studies the wonderful exhibit which she makes here in all departments can fail to be impressed with the fact that she is fast taking rank industrially and commercially with the most advanced nations of the world.

## SUMMARY OF ACTION OF MASTER MECHANICS' ASSOCIATION ON TECHNICAL SUBJECTS.*

(1) Standard Nuts, Standard Screw Threads, Bolts, Bolt Heads and Standards for Bar Iron.—In 1870 the Association recommended the formal adoption of the U. S. Standard nuts. In 1884, it adopted Pratt & Whitney limit gages for round iron to be used for Sellers' standard thread taps. In 1891, reaffirmed formally the sandards of 1870 and of 1884. In 1892, adopted the standard U. S. Standard sizes of nuts and bolt heads and urged on the members of the association a rigid adherence to the same. In 1899, Briggs' standard wrought iron pipe threads were adopted for wrought iron pipe and couplings as standard.

(2) Boiler Construction.—In 1871, the association recommended steam as better than hand riveting. In 1872, recommended all holes in longitudinal seams be drilled and made to match by reaming rather than by the use of a drift pin; also that hollow stay bolts be used. In 1881, recommended machine riveting, especially steam riveting. In 1885, recommended making a clean metallic joint between surfaces to be calked with waste wet with a weak solution of sal ammoniac and hot water. In 1885, that in hydraulic tests for locomotives, hot water 25 lbs. above working pressure be used. In 1889, recommended the double riveting of the foundation or mud rings on boilers. In 1894, drew up specifications for boiler and fire-box steel. In 1895, approved a report showing best methods of making a riveted joint and best designs therefor. In 1899 approved a report on best method of applying stay bolts to boiler. In 1880, that in crown bar boilers it was essential to use sling stays from the crown bars to the outside shell of the boiler. In 1894, it was recommended that in view of the greater breakage of flue sheets in radial stay boilers, due to the rigid strain of the chrown sheets and placing of flues too close to the flange of the sheet, that flexible sling stays should be used to support the crown sheet at the front end. In 1896, it was resolved as the sense of the meeting that a radial stay boiler was as safe as a crown bar boiler and more easily and economically kept clean and in repair. In 1886, a committee reported on the best plan of removing, cleaning and resetting boiler tubes, and it was voted as the sense of the meeting that it was unnecessary to bead the front end of flues. In 1880, a committee reported that it was almost the unanimous sentiment of the association that the water space around the fire-box should be from four to five inches; that the water bridge between flues should be ¾-in., with 2-in. flues, and that the flues should be set vertical, so as to allow better circulation. In 1895, specifications and tests were offered and adopted for boiler tubes. (See also page 296, 1899.) In 1895 (also), the question was discussed as to a uniform method of computing boiler tube heating surface. Three locomotive works and the Pennsylvania R. R. reported that they figured the heating surface by figuring the outside diameter of tubes, whereas one locomotive works figures the heating surface by figuring the inside diameter of tubes. In 1896, a slight change was made in the standard size to suit standard gage.

(3) Standard Tender and Car Axles.—In 1879, the association adopted the journal, 3¾ × 7 ins., for cars and tender axles of 40,000 lbs. capacity. In 1881, this was reaffirmed. In 1890, adopted the M. C. B. 60,000-lb. axle with journal 4¼ × 8 ins., for heavy tenders. In 1891, these recommendations were reaffirmed as recommended practice.

(4) Side Rods.—In 1882, the association favored the "I" beam section of side rod. In 1884, approved formulae offered by Mr. F. W. Dean for design of such sections. In 1893, favored the manufacture of fluted or "I" beam side rods by machine work rather than by forging them out.

(5) Wire Gages for Wire, Tubes and Sheet Metal.—In 1882, the association adopted the Browne & Sharpe micrometer gage, which was reaffirmed in 1891. In 1895, adopted an elliptical notched decimal gage. (See also page 291, 1899.)

(6) Gage of Wheels on Axles for Standard Gage Track.—In 1884, the association adopted 4 ft. 5⅝ ins. as the standard width between backs of wheels for tender trucks and locomotive wheels, with the limits of 4 ft. 5¼ ins., and 4 ft. 5½ ins. These conform with the M. C. B. standard.

(7) Standard Diameters of Driving Wheels, and Tires for Driving Wheels.—In 1886, certain standard diameters of wheels and standard sections of tire were adopted, varying from 38-in. to 66-in. diameter, inclusive. In 1877, a further report on this matter with the exact inside diameters of tires was adopted and the M. C. B. standard tire section also adopted. In 1893, standard outlines for flanged and plain tires were adopted, and standard sizes of wheel centers from 70-in. to 90-in. were also adopted. (See also pages 293 and 294, 1899.) In 1887, decided that the manipulation of the sand and handling of the brakes by engineers had a great deal to do with the wear of tires. In 1895, an elaborate report on the wear of driving-wheel tires was submitted showing six different causes. In 1896, the question of counterbalance was considered and its relation to driving-wheel tires pointed out. In 1896 (again), a report was submitted pointing out the best design for deciprocating parts in order to reduce the weight of counterbalance as much as possible.

*Abstract of the appendix to the committee report on the extent to which the recommendations of the American Railway Master Mechanics' Association have been put in practice; presented at the convention at Saratoga, June 21.

(8) Relative Proportions of Cylinder to Boilers and Grate Area.—In 1887, a formula for the proper proportions of locomotive cylinders was offered. (See page 43.) In 1888, recommendations giving limits for these proportions were offered and approved. In 1897, a report was made giving valuable data as to the proper ratios of heating surface, grate area and cylinder volume for passenger and freight service, burning anthracite or bituminous coal.

(9) More Economical Combustion.—In 1881, comparatively high exhaust nozzles were recommended as the best practice. In 1888, the conclusion of a committee reporting on the subject of extension fronts, brick arches, etc., concluded that brick arches were an excellent thing, but should not come closer than 1 in. from the side sheet or 2 ins. from the flue sheet; that 90 lbs. of coal per sq. ft. of grate area per hour was about the maximum economical rate of combustion. In 1890, another committee on brick arches stated that the evidence was overwhelming in favor of the brick arch and extension front end. Angle irons and studs for brick arches were preferred to circulating pipes. In 1896 and 1897, a committee offered a very complete report on the proper height of exhaust nozzle and form of stack, recommending a tapered choke stack. In 1899, the association decided by vote that it was not desirable to use bars in the exhaust nozzle.

(10) Testing Laboratories for Railways.—In 1891, a very complete report was submitted on the subject of testing laboratories for railways, showing their proper organization and province.

(11) Testing Materials.—In 1892, the association accepted a report making six conclusions, the most important of which was that steel should not be worked at a temperature between normal and a perceptible red heat known as "blue heat." In 1896, the association again decided that it was of great importance in flanging steel that it should not be worked below a cherry red heat.

(12) Treatment of Employees.—In 1886, a resolution was passed that the association deprecates giving testimonials or recommendatory letters for publication, and enjoins all to restrict matters of this nature to letters of inquiry. In 1891, a report was submitted giving advice to employers as to the best method of examining engineers and firemen, including suggestions on the education of firemen. In 1898, a report was submitted on the subject of apprentice boys and a code of rules adopted by the association to govern their promotion.

(13) Compound Locomotives.—In 1893, the association decided that the compound is suitable for freight service, but that its availability in passenger service was undetermined. In 1899, the association decided that a by-pass valve to relieve the vacuum in the low-pressure cylinder when drifting was very important.

(14) Standards for Boiler Attachments.—In 1893, the association listened to a report making eight recommendations looking to increased safety, and adopted a resolution that the water glass, although a convenience and an additional precaution against low water, was not absolutely necessary to the safe running of locomotives.

(15) Tonnage Rating for Locomotives and Ton-Mile Basis for Statistics.—In 1898, the association considered favorably a report on tonnage rating, and in 1899 adopted a resolution that it was the sense of the meeting that the ton-mile basis for motive power statistics is the more practical and encourages economical methods of operating, etc.

(16) Chilled Cast-Iron vs. Steel-Tired Wheels for Cars and Locomotives.—In 1888, the association approved specifications submitted by a committee for the manufacture of chilled wheels, giving a test, form of contract and service guarantee. In 1899, in a report on the relative merits of cast wheels and steel-tired wheels for locomotive and passenger cars, a recommendation (see page 127) was made as to the best method of keeping a record of the mileage of wheels.

(17) Best Metal for Locomotive Cylinders and Cylinder Bushings.—In 1896, the association accepted a report on cylinder bushings, making five distinct recommendations. In 1897, accepted a report of a committee making four recommendations in regard to best metal to be used for cylinders, valves and valve seats.

(18) Locomotive Statistics.—In 1872, the association adopted a report fixing an arbitrary mileage to be computed for switch engines at six miles per hour of actual service, for local freight engines 6% for switching and also that new engines to replace vacant numbers should be charged to repairs, except any excess in cost over the old ones.

## BOOK REVIEWS.

RAILROAD CONSTRUCTION.—Theory and Practice. A Text-Book for the Use of Students in Colleges and Technical Schools. By Walter Loring Webb, Assoc. M. Am. Soc. C. E., Assist. Prof. of Civil Engineering in the University of Pennsylvania, etc. New York: John Wiley & Sons. Cloth; 8vo.; pp. 456; illustrated. $4.

This book deals with railway work from the surveys to the track construction, and is more adapted for the use of the student than the engineer, as may be judged from its sub-title. The distribution of the contents may be summarized as follows: Surveys and alinement, 63 pages; earthwork, 80; trestles, bridges, culverts and tunnels, 68; track, 80; instruments and logarithmic tables, 150. The first portion deals briefly with the principles and practice of location and the field work for setting out curves. The transition curve method described is that of a multiform compound curve, which will approximate closely to a spiral. Nearly one-fourth of the book (exclusive of tables) is devoted to the subject of earthwork, with the methods of surveys and calculations of quantities. A system of computation from cross-sections by means of a slide rule is given, and the book has the slide rule (printed on card) in a pocket of the cover. The methods and cost of grading and excavation are also dealt with.

In regard to structures, Mr. Webb says that permanent trestles of extreme height are called viaducts, a definition which is hardly satisfactory, and while a comparison is drawn between trestles and embankments, nothing is said about filling in trestles, although this is a class of work which is carried out very extensively. The different systems of tunnel construction are quite fully described. The portion devoted to track is limited, 25 of the 80 pages being occupied by mathematical discussions of switch and crossing work. The subject is fairly well handled in its brief scope, but the relations of the carbon contents to the physical properties of rails are so stated as to imply that high-carbon rails are necessarily brittle, which is very far from being the case. The logarithmic tables are well printed. The index is so unsystematic as to be practically useless in finding anything but the general headings.

A BRIEF HISTORY OF MATHEMATICS.—An authorized translation of Dr. Karl Fink's "Geschichte der Elementar-Mathematik." By Wooster Woodruff Beman, Professor of Mathematics in the University of Michigan, and David Eugene Smith, Principal of the State Normal School at Brockport, N. Y. Chicago: The Open Court Publishing Co. Cloth; 8 × 5½ ins.; pp. 333; illustrated with symbols. $1.50.

The science of mathematics, historically considered, had its beginning with the earliest civilization of the Egyptian and Babylonian; though previous to their time there was a savage notation by counting pebbles, shells or the fingers. Dr. Fink begins with this earlier method of counting, as practiced among savage races, and then passes to the number systems and symbols as these successively appeared. Common arithmetic was developed among the Egyptians and passed to the Greeks, Babylonians and Romans. The Arab, borrowing from the Greek and the Hindu, gave us our numerals, and developed the science of algebra, though this science was previously well known to the Greeks, Hindus and Chinese. Geometry is again traced back to the Egyptians and Babylonians; was transplanted to Greek soil and passed through the Arab to the nations of the west. Trigonometry was developed by the ancients for purposes of astronomy; and then employed by the Greeks and Arabs in calculations. Ptolemy introduced a formal spherical trigonometry in his astronomical calculations, and he followed the Babylonian in dividing the circumference into 360 degrees; but he also bisected these degrees. Under these separate heads Dr. Fink takes up the whole history of the science of mathematics and minutely discusses the development of each in a most interesting manner. At the end of the volume is a valuable collection of biographical notes, relating to the men who have taken part, at any time in the world's history, in the development of this science.

THE WATER-WORKS DIRECTORY AND STATISTICS.—With a List of Chairmen, Managers, Engineers and Secretaries, and List of Associations of Engineers and Managers. London: Hazell, Watson & Viney. Cloth; 6 × 9 ins.; pp. xxix. + 128. Six shillings in Great Britain; $2.40 in America.

This is a valuable and interesting volume devoted to the water-works of Great Britain and Ireland, and such foreign works as have offices in London, there being about twenty-five of the latter. The general plan of the book is much like "The Manual of American Water-Works," only its scope is not so comprehensive. Aside from information relating to the location of the town and the history of the works in question, the principle items given are as follows: Population and area supplied, death rate, source of supply, water hard or soft (often with degrees of hardness), storage capacity, total yearly and per capita daily consumption, water rates and total revenue, length of mains, number of meters, filtration employed and officials.

LA GARANCE ET L'INDIGO.—Par George F. Jaubert, Director de la Revue Generale de Chimie pure et appliquee. Docteur es Sciences, etc. Paris: Gauthier-Villars. Paper; 7½ × 4½ ins.; pp. 166. 2.50 francs.

This is a historical and industrial treatise upon the dyestuffs, madder and indigo; giving the processes of cultivation and manufacture, analysis, and the dyes derived from them. In connection with the cultivation of indigo and its commercial varieties, artificial indigo and its production are fully treated.

SPECIFICATIONS IN DETAIL.—By Frank W. Macey, Architect, London; E. & F. N. Spon. New York: Spon & Chamberlain. Cloth; 6 × 9 ins.; pp. 622; numerous illustrations. $8.

This is by far the most comprehensive book on architectural specifications which we remember of having seen. The author presents a variety of methods for carrying out many of the details of the different classes of work, and makes free use of notes and comments to indicate the advantages and disadvantages of the various methods. Particularly helpful are the numerous sketches of details, of which there are several hundred. Drainage, plumbing, heating, ventilation, paving, road-making and electric lighting are the subjects of greatest interest to engineers in this volume. A great variety of foot-paths and sidewalks are included. The index is very full, covering 94 pages.

# ENGINEERING NEWS
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In accordance with a promise made in our issue of June 14, we have reviewed, elsewhere in this issue, the progress thus far made in the United States towards securing uniform municipal statistics. Doubtless most of those who read the article will be surprised to learn how many activities there are tending towards uniform municipal records and reports. But although the list is long the sum total of results is small, compared with what remains to be accomplished. The National government has done, and in the nature of the case can do, but little to secure a uniform system of keeping municipal records. Although there are many States which have done something to secure uniformity, the number of those which have taken up any single line of municipal undertakings is small, and of those that have made a decided success of the attempt is smaller still. This is particularly true of the work in which engineers are most interested, such as sewers, pavements and roads, water-works, lighting plants and street railways. In addition to the comparatively small amount of work done by the several States, that accomplished in the different commonwealths is generally so dissimilar as to rob it of a large part of its possible value. Nevertheless, it is very encouraging to see that so much has been done by State legislatures and by the administrative officers created under their acts. The movement as a whole is well under way, and is bound to increase in volume and speed. What is most needed now is unification of methods, both within each State and between the several States. Of the various possible means of bringing this about, as well as extending the movement as a whole, no agency is more promising than the various organizations of engineers, municipal officials and others interested in good city government. Much that has been accomplished thus far is largely due to these societies, and to them we must continue to look. Made up, as their membership is, of citizens from various parts of each State, and from most or all the States of the Union, their influence upon State legislatures is often very great, and by well-directed effort may be increased. The members of these societies not only realize more keenly than the general public the value of uniform statistics; they are also peculiarly fitted by education and professional experience to devise a system for securing such uniformity. It is essential to success that there should be more co-operation between the different societies. For instance, some fifteen years ago both the American and New England Water-Works Associations drew up, each independently of the other, a scheme for the annual reports of water departments. Two years ago, a committee of the American Society of Municipal Improvements drew up still another scheme. In pleasing contrast is the later action of the three organizations, interested in street railway statistics, which have united on a schedule for accounts and reports, as outlined in our review. Many other lines of criticism are suggested by a study of the efforts towards uniformity which we have recorded this week. We have space for only one suggestion, which springs from what has immediately preceded. It is that the committee of the American Society of Civil Engineers and of the American Society of Municipal Improvements, together with the Secretary of the National Municipal League—all of whom are authorized to co-operate with committees appointed by other societies—bend their energies first of all to secure united action on the part of all societies that are seeking to secure uniform municipal statistics. As we tried to show in our issue of June 14, such uniformity must be attained as a prerequisite to national municipal statistics. There are many other organizations that would gladly join in this work, if only it was brought to their attention. Before the end of the year the following societies (besides those already having committees), all national or international in scope, and all devoted wholly or in part to municipal affairs, will hold their annual conventions: Central States Water-Works Association, New England Water-Works Association, International Association of Municipal Electricians, American Public Health Association, and the League of American Municipalities. If strong committees from these societies could be appointed to co-operate with the representatives of the three organizations first named, much might be accomplished in the interest first of securing and afterwards of collecting uniform municipal statistics. The organizations already named could expect the hearty co-operation of a host of State and local engineering societies, State municipal leagues and other associations. These State and local societies would not only give valuable suggestions, but they would have a great and almost necessary influence in securing the legislative action required to ensure uniform municipal records throughout the country.

## ARE THE LAST KNOTS OF SPEED IN TORPEDO VESSELS WORTH THEIR COST?

It is not often realized to what a large degree modern naval construction is mere theoretical experiment. All other engineering works are put into practical use when completed, but the machinery of warfare can at best be only tried in mimic war, and this necessarily falls far short of reaching the conditions of actual destructive combat. Thus in naval construction the best that can be done is to forecast, as well as possible, the conditions to be met, and then provide such apparatus as seems best suited to meet these conditions.

Unfortunately, naval construction is not always planned so intelligently as this. Popular ideas often have as much to do in shaping the course of the naval appropriation bill as the studies of naval experts. Then, too, there are fads and fashions in the navy as elsewhere, and these sometimes run a long course before they are discarded.

There is considerable reason to believe that one of the fads and fashions of the present day for which little good can be said is the modern high speed torpedo vessel. At the present time every modern navy of any pretensions possesses, or is having constructed, high speed torpedo vessels. There is, in fact, a race for speed supremacy. Each new record-breaker is hailed as an advance in naval construction, and the navies of different nations, and the builders of this class of vessel are competing with each other as vigorously as if they were building yachts to win the America cup.

It is worth while to ask, therefore, what these phenomenal bursts of speed are likely to be worth in actual warfare. We may face the question more intelligently and with less prejudice, perhaps, by tracing the evolution of the modern high speed torpedo vessel.

The use of small boats to place and fire explosives against the side of an enemy's vessel is an old idea. Considerable ingenious and daring work of this sort was done during the Civil War. The modern torpedo vessel, however, may be said to have had its origin with the invention of the Whitehead or "fish" torpedo, in the '70's. The plan of using special small fast vessels to carry these torpedoes and discharge them against the enemy's ships was at once suggested and was promptly acted upon. France was the first country to take up with energy the construction of torpedo vessels. She was then as now greatly overmatched by England in naval strength. War between the two nations would mean the blockading of French ports—by British battleships. A large fleet of torpedo boats was built for the French navy, and it was loudly declared that the day of the armored battleship was over, and that no fleet could blockade a port where torpedo boats could dart out and launch their hostile missiles at the armored vessels.

England's answer to this was the building of a class of vessels which were named torpedo gunboats. The French boats had speeds of about 20 knots. The torpedo gunboats were a little larger vessels, with slightly higher speeds. Their duty was to guard the larger vessels of the fleet from the attack of torpedo boats. Manifestly, to effect this they would have to move with and operate with a fleet, and for this they were found to be eminently unsuitable. They were not good sea boats, and their coal capacity was too small. Besides this, the speed of torpedo boats was raised, so that the ability of the gunboat to catch and destroy them became doubtful.

The demand thus arose for a larger boat, and especially for one fast enough to catch and powerful enough to destroy any torpedo boat which might offer to attack the armored ships of a fleet. The result of this demand was the English "torpedo boat destroyers," as they were named. These vessels were made to reach a higher speed than anything before attained. The idea then became current that speed was the great desideratum in this class of vessel, and the race to attain high speeds began. The leading builders strove to outdo each other in crowding the greatest horse-power of boilers and engines into the smallest space, and building both in the lightest possible manner. Steam pressures and piston speeds were increased, and to enable still greater horse-power to be crowded into a hull of given displacement, the weight of the hull itself was pared down, by the use of thinner plates and lighter framing.

The result of all this is the modern high speed torpedo vessel, with a displacement of perhaps a thousand tons, horse-power of 8,000 or more, and capable of a burst of speed of above 30 knots in smooth water. To make possible this enormous speed everything in the vessel is made secondary to the propelling machinery. The hull is so light and frail a structure that the whole vessel vibrates like a taut string with the motion of the machinery, and the force of the waves alone has bent and twisted the bow of a vessel as if it had been in a collision. The life of a vessel with plates so thin is a very short one, even with the best of care to reduce corrosion.

Again the natural result of the extreme lightening of the propelling machinery has been numerous breakdowns and accidents, many of them attended with most distressing casualties to officers and crew. Service on a high speed torpedo vessel deserves to be ranked as "extra hazardous." It may be said that hazard is inseparable from war;

boat, while men will willingly face danger from an enemy's weapons, needless hazard from one's own weapons has a greater tendency to unnerve men and destroy the morale of a force.

Besides the danger, the perpetual discomfort of all hands on board a high speed torpedo vessel is not a thing to be disregarded. It is coming to be well recognized, now, that the best of weapons are useless, on sea or land, without the training and skill of the men behind the guns. The fighting force, afloat or ashore, which is best taken care of, has a real advantage. Food and rest are as vital necessities to the human machine as coal and water to a steam engine. In the high speed torpedo vessel, however, the quarters of officers and crew are cut down to make more room for machinery. It was the testimony of many officers in the Spanish-American war that sleep on the torpedo vessels was practically impossible.

Space permits no greater detail in enumerating what high speeds in torpedo boats costs. Now let us ask what we gain by it. It will be recognized at once that the case is far different from that of a battleship or cruiser. Speed in such a vessel enables her to escape from a pursuing vessel of superior fighting power, or on the other hand, to overhaul and capture or destroy one for which she is a match.

The torpedo vessel, however, has no business in time of war to cruise on the seas alone, or away from a base. The only case in which she might be properly set to catch another vessel would be when she was operating with a fleet, and charged with the duty of capturing or driving off torpedo vessels of the enemy. The modern destroyer, however, is ill adapted to such work. Her inability to endure heavy weather, and to maintain cruising speed in rough water, with the necessity of frequent coaling, make boats of this class a very doubtful advantage in the movements of a fleet. As scouts with a blockading fleet, they may be made useful; but even here, a vessel better able to endure rough weather, with less engine power and more battery, and better able to maintain her post without constant absence for coal and supplies, would promise greater usefulness.

The real value and usefulness of the torpedo vessel in time of war, then, is for the duty for which she was originally designed, the launching of torpedoes against the heavier ships of an enemy's fleet. Her opportunity to do this will come when a blockade is attempted, or when a port is threatened; seldom at any other time. For this work, however, her usefulness is beyond question. Assume for example that a hostile fleet should attempt a blockade of some of the fortified ports on the Atlantic coast. The danger to such a fleet from the attack of torpedo boats would be a most serious one.

It will be understood, of course, that night, or a time of fog, will be generally chosen for torpedo boat attack. The search-light aids the ship to detect and repel such attacks in the night; but it is of no avail in time of fog. At such times all that can be done is to surround a fleet with picket boats, but these are after all little protection. No such cordon can be made so complete that a torpedo boat might not get through with little harm, or even undiscovered. It is hardly too much to say that in such a case she would have at her mercy the first vessel of the enemy which she might run across.

In this field, then, the value of the torpedo boat is unquestioned. As a means of harbor defence they occupy a place that nothing else can replace. Outside of this their usefulness is exceedingly doubtful.

It will be apparent that if the torpedo boat makes her attack in a fog, high speed is of no benefit whatever. She will hunt for her foe in the mist, making the least possible noise to avoid giving warning of her approach, and with everything in readiness to launch her powerful weapon the moment an enemy's vessel is discerned.

The sole argument of the advocate of high speed for torpedo boats is as follows: That if the boat makes her attack in daylight, or is discovered, by a searchlight when attacking at night, her chances of a successful attack are proportionate to her speed. To illustrate; suppose the attacking boat is discovered when three miles away and discharges her torpedo when within half a mile of the enemy's ship; she has then 2½ miles to run in the so-called danger zone, and the higher her speed the quicker she can pass through it and the less her chances of being disabled before coming near enough to discharge the torpedo. This and only this is what we gain by high speed in torpedo vessels, and are we not paying too dearly for it. Suppose we compare a 25-knot boat and a 30-knot boat, each passing through a danger zone of 2½ miles. The slower boat would pass through it in six minutes; the 30-knot boat in five minutes. Taking the speed as proportional to the cube of the power, the 30-knot boat must have about 1¾ the power of the smaller boat. Is it worth while to thus increase the power, and pare down the plates until the vessel is vulnerable as an egg shell, and all that she may stay in the danger zone five minutes instead of six minutes?

The United States, in building its new navy long ignored the action of other nations in the construction of torpedo craft, and up to a short time ago the navy possessed only a very few vessels of this class. When the Spanish war opened the nation's purse strings for anything needed to strength and perfect the navy, the lead of foreign nations was followed in this matter, and a who'e fleet of torpedo vessels was provided for and put under contract.

It will hardly be claimed, however, that we have had a high degree of success in building these vessels. Some of the contracts were taken by builders with little knowledge of the real requirements of such vessels, and less ability to fulfil them. The record of breakdowns on their trial trips with these vessels has been a long and mortifying one. In view of these circumstances it is some comfort to reflect that the speed which some builders have found it so difficult to attain means much less than is often popularly supposed in the real efficiency of the boat in actual warfare.

In conclusion, before further additions are made to our torpedo fleet, it would seem that the whole subject should be thoroughly investigated. If, as seems now likely, torpedo boats are to be used for harbor defence only small vessels, much like the original torpedo boats, are likely to prove more efficient than the modern destroyer type. If a vessel is desired to operate with a fleet, capable of serving as a scout, despatch boat and picket, of warding off attacks of other torpedo craft, and incidentally of launching torpedoes at the enemy's vessels as opportunity offers; if a boat for this class of service is desired, then she should be designed for it, and made staunch and seaworthy, with good coal capacity and propelling machinery of entire reliability.

The modern high speed torpedo vessel of the "destroyer" class is a marvelous achievement of mechanical and marine engineering. It has not been without value in advancing the art of shipbuilding and marine construction in the same manner as the high speed yacht; but that its ability to make a phenomenal burst of speed will be of value in actual warfare, is yet to be demonstrated, either theoretically or practically.

## LETTERS TO THE EDITOR.

### Tracklaying by Machinery.

Sir: I note with interest your article on tracklaying by machine on the Canadian Pacific Ry., in your issue of June 14, and wish to inform you that we are using the same machine (Roberts) for laying track on the extension of the St. Louis & San Francisco Ry. from Sapulpa, Ind. Ter., to Sherman, Tex., a distance of 208 miles. We have no difficulty in laying and full-tieing 6,000 ft. of track each half way of 5 hours, or 2.27 miles per day of 10 hours.

Very truly yours,

J. F. Hinckley,
Chf. Engr., St. L., Okla. & So. Ry.

Sapulpa, Ind. Ter., June 23, 1900.

### The Possible Use for Oxygen in the Production of Steel.

Sir: Referring to the editorial in your issue of June 14, on the statement lately made by Prof. Morton of Stevens Institute, regarding the production of cheap oxygen from liquid air, as claimed by Prof. Tripler, I take the liberty of submitting a few observations. I entirely agree with Prof. Morton that the proposition to obtain pure oxygen from liquid air is not practicable, since its cost is $10 per 1,000 cu. ft., whilst we already obtain oxygen by the electrolysis of water by means of the Garuti apparatus (which I have the honor to represent in this country), at a cost of 0.125 francs per cubic meter, or $3.54 per 1,000 cu. ft., which it will be seen is only about one-third the cost of producing it by liquid air. It necessarily follows that cheap oxygen cannot be produced by liquid air, as is stated by Prof. Tripler. I do not agree with Prof. Morton, however, that there is no market for cheap oxygen.

The numerous applications of oxygen for medical purposes alone could be made of enormous profit. We know that it has only been the great cost of oxygen that has until now been in the way of its free use by the medical fraternity. It is a wonderful cure in many diseases, and there is no doubt of its free use by the physicians could it be had at the low price as previously indicated. This is clearly proven in the countries where the Garuti apparatus has been introduced and used.

There is large markets for oxygen and hydrogen, in the proportions as obtained by the Garuti process, for fuel at the highest temperature. There are already in Europe glass factories which use these gases exclusively for fuel. They are also used in the welding of metals, such as iron, steel, etc., which in the tests have been found to withstand a pressure of 1,500 lbs. per the sq. in.

The largest market for these gases, however, is now opening in this country for the production of steel. Mr. Garuti, the inventor of the apparatus before mentioned, has been recently experimenting both at the Cockerill factory at Seraing, Belgium, and at the Societa Fonderia Milanese d'acciajo in Italy, in the decarbonization of iron ore by means of oxygen in the production of steel. These experiments have been so successful that on January 31, 1900, the Italian Government granted a patent to the latter concern, for this process of smelting iron ore and the production of steel.

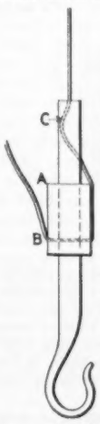
There is no doubt that on account of the great output of steel and competition in steel work that the manufacturer is constantly on the lookout for any and every improvement that will afford even a small saving in the cost of production. It follows, therefore, that as soon as this new method of producing steel shall be known and put in use here, a great demand for cheap oxygen will arise and an enormous market be established.

Respectfully,

Chas. Prelini.

3462 Broadway, New York, June 19, 1900.

### Device for Holding a Plumb Bob Line.




Sir: I send you a sketch of a device for holding a plumb bob line which may be new to some and which I have found very convenient. I believe it is not patented, although I have never investigated the matter. A represents a sleeve which slides on the shaft of the hook; at B there is a hole drilled through shaft and sleeve, through which the line passes, thence down through the crooked hole at C and out of the end of the shaft. The advantages are: Ease of adjusting the bob, and also having the whole length of the line at one's disposal, which is not the case with any like simple device of which I know.

Yours truly,

A. Rogers.

Warren, Pa., May 30, 1900.

### Stresses in Circular Flat Plates.

Sir: In your issue of April 5 is printed a communication from Mr. Luigi d'Auria on the subject of flat plates, in which he deduces a formula for proportioning such plates. Plainly stated, his method is as follows: He takes out of the plate (assumed to be fixed around the edges) a segment of a spherical shell. Supposing the spherical shell of which this is a segment to have an internal pressure equal to the pressure on the plate, he finds the tension per square inch on the shell. The thickness of this shell is taken at one-half the thickness of the plate. This segment is then removed, and it is seen that if the remaining parts of the flat plate are brought together they will very nearly fit each other and make a second flat plate of half the thickness of the original plate. Then a second spherical shell is taken out of this and its strength computed for tension only. The remaining parts are then brought together and a third segment taken out. This is carried on ad infinitum, and the strength of the plate is found as a total of the strength of the segments.

It seems to me that this is far from rational, for several reasons: (1) None but tensile stresses are taken into account. It can scarcely be disputed that the inner layer of the plate (toward the pressure) is in compression, just as with a beam in bending. (2) The value $h^3$, or the square of the thickness of the plate, is disregarded twice. This might affect the result considerably in the case of thick plates. (3) The same reasoning could be applied to a beam of rectangular cross section and fixed ends, by taking out a segment of a cylindrical shell $\frac{h}{2}$ in thickness, then one $\frac{h}{4}$ in thickness and so on, and finding the fiber

stress assuming tension only. It will be found that

$$f = \frac{3\ Pr^2}{2\ h^2}.$$

In a beam with fixed ends, by the common theory of flexure, the extreme fiber stress for a rectangular section unity in width is

$$f = \frac{Pr^2}{h^2}$$

where P = load per unit of span, r = ½ span, and h = depth. If this method does not give correct results for beams with fixed ends, I see no reason why it should do so in the case of flat plates.

The formula is compared with Prof. Lanza's, but no mention is made of the fact that Poisson's ratio is ignored, although Prof. Lanza's formula is based upon the theory of that ratio.

While my communication on this subject in your issue of March 8 did not call for a reply, I note that Professors Lanza and Church have failed to assure us on the strength of Poisson's ratio that it would be perfectly safe to design a hub made of a flat plate strong enough to take a little over one-half only of the tension tending to pull it apart. I would like to ask further if it would be quite safe to proportion a spherical shell for 5-9 of the internal pressure, and let Poisson's ratio take care of the rest. Sincerely yours, Edward Godfrey.

Monongahela Bank Building, Pittsburg, Pa.,
May 23, 1900.

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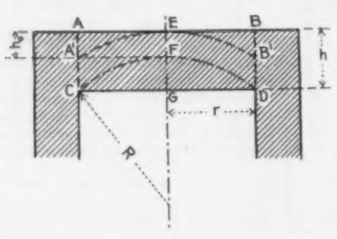
(We submitted a proof of this letter to Mr. d'Auria, who has sent us the following reply.—Ed.)

Sir: The problem which I proposed to solve in my letter of March 10, 1900, published in your issue of April 5, 1900, relates to stresses in circular flat plates with edges fixed all around, as shown in the accompanying figure, and it seems evident that the bending of a plate under such conditions can involve none but tensile stresses. It is, therefore, remarkable that Mr. Edward Godfrey gives as his first reason against the rationality of my method, that "none but tensile stresses are taken into account." Continuing, he says: "It can scarcely be disputed that the inner layer of the plate (toward the pressure) is in compression, just as with a beam in bending." He seems




to forget that a beam in bending experiences compression only because the beam is assumed to be free endwise, which is the case considered in the common theory of flexure. Were the ends of the beam fixed rigidly, as in the case of the plate considered in my problem, then compression would be impossible. Prof. John Goodman, in his "Mechanics Applied to Engineering," referring to the bending of beams (page 337), says:

> In all these cases the beam is shown built in at both ends. The beams are assumed to be free endwise, and guided so that the ends shall remain horizontal as the beam is bent. If they were rigidly held at both ends, the problem would be much more complex.

This shows why Mr. Godfrey's application of my method to the determination of the extreme fiber stress for a rectangular beam "with fixed ends," does not agree with the common theory of flexure. The latter supposes a beam with built-in ends, while my method applies to beams held rigidly at both ends, a problem which, as Prof. Goodman says, is "much more complex," and which is very simply solved by my method. This disposes of Mr. Godfrey's third reason why my method is not rational.

In order that the reader may better understand the rationality of my method, imagine a circular flat plate of radius r and thickness h rigidly fixed all around its edges, as shown in the figure; and let the problem be to find the pressure p corresponding to the extreme fiber stress. From equation (1) in my first communication, we get

$$p = 2\,f\,\frac{h_0}{R}, \qquad (a)$$

in which p is the pressure, h is the thickness, and R the radius of the spherical shell of greatest strength within the metal of the plate. The value of R can be expressed in terms of r, h and $h_0$, as follows:

$$R = \frac{r^2 + (h - h_0)^2}{2\,(h - h_0)}, \qquad (b)$$

and therefore we get

$$p = 4\,f\,\frac{h_0\,(h - h_0)}{r^2 + (h - h_0)^2}. \qquad (c)$$

Determining $h_0$ so as to make p = maximum, we get

$$h_0 = h\,\frac{r^2 + h^2}{h^2}\left\{1 - \sqrt{\frac{r^2}{r^2 + h^2}}\right\}. \qquad (d)$$

which is expressed in terms of known quantities. With this value of $h_0$ we determine R and p corresponding to the first spherical shell of greatest strength. Computing the amount of material left in the original plate when such shell is deducted, we can find the thickness of a second plate of radius r, and therefore we can find the pressure p, which corresponds to the spherical shell of greatest strength within the second plate. Continuing this operation ad infinitum, we would certainly and rationally find the exact total pressure, or $\Sigma\ p = P$, per unit area of the plate. Of course, if the plate had been supported only, or built in at the edges, so as to allow sliding, my method could not be properly applied, but the fact that Prof. Lanza's formula for such cases does not differ more than 5% from the formula deduced by me for plates rigidly fixed all around (independently of Poisson's ratio) shows that the two problems cannot differ very much.

There is now another reason left, reason (2), which Mr. Godfrey gives against the rationality of my method. This is: "The value $h^2$, or the square of the thickness of the plate, is disregarded twice. This might affect the result considerably in the case of thick plates." Those who have read my paper will remember, perhaps, that it is not $h^2$ but $\frac{h^2}{r^2}$ which is disregarded; that is, the square of the ratio of thickness to radius of plate. If Mr. Godfrey had applied a little arithmetic, he could have seen that when the thickness, for example, is ¼ of the radius of the plate (a ratio rarely exceeded in practice) $h_0$ = 0.51 h, which is only 2% greater than $\frac{h}{2}$, which I get by disregarding $\frac{h^2}{r^2}$ in my formula. But we must remember that the difference between the exact and the approximate value of $h_0$ does not imply an error of the same magnitude in the final result, because when we take $h_0$ = ½ h, instead of $h_0$ = 0.51 h, for instance, we get in the first case a larger residual of metal than in the second case, and by taking out from this larger residual the successive spherical shells of greatest strength a quasi-compensation is effected which evidently reduces the difference in the final result to almost nothing.

Luigi d'Auria.

Drexel Bldg., Philadelphia, Pa., June 9, 1900.

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## THE EXHIBIT OF TYPICAL AMERICAN BRIDGES AT THE PARIS EXPOSITION.

By Geo. L. Fowler.*

(With two-page plate.)

There is on exhibition in the Transportation Department of the Paris Exposition a series of drawings illustrating American locomotives, cars and bridges that were executed for the United States Commission under the direction of the author. Through the courtesy of Mr. Willard A. Smith,, the Director of Transportation for the United States, he is enabled to present in Engineering News engravings of that portion of the series relating to bridges. These are ten in number, in which there was no attempt to illustrate the development of bridge construction in this country. The number of drawings available for the purpose was too small for that, so the work was confined to the illustration of typical designs as embodied in some of the most notable railway bridges that have been constructed.

The first of the series, Fig. 1, illustrates the earliest railway bridge that was built in the state of Pennsylvania. Only one span is shown, but that is typical of the others. At the time of its construction (1832) it was the longest railway bridge in the world; its length being 984 ft. over all. The original bridge consisted of seven spans. When the Belmont plane was abandoned it was sold to the Philadelphia & Reading R. R. Co. Its site now forms part of the main line of that company. Before this bridge was constructed a ferry was used to transport passengers and freight across the Schuylkill River to the foot of the Belmont plane. Like all of the early American bridges this one was constructed entirely of wood. It consisted of built-up arches footing against stone piers and carrying a through truss on the floor of which the rails were laid. This is the only one of the early bridges that is shown and is followed by four drawings representing three types of modern construction.

*53 Broadway, New York city.

Of these, Fig. 2 represents a modern form of railway bridge known as a riveted truss. It will be seen that both the compression and tension members are formed of heavy box girders built up of channels and plates securely riveted. The panel posts and diagonal braces are latticed members formed of channels and short diagonals. The floor is suspended from the lower or tension member. Such bridges are used for heavy traffic and are of a very substantial construction. Fig. 3 is merely an end view of the same bridge, for the purpose of illustrating the appearance of the portal and showing the method of laying the solid floor with the ties held by ballast as in the surface construction.

The second type of through truss bridge is shown in Fig. 4, which is known as a pin-connected structure. The end posts and compression members are in the form of a box girder, as in the preceding case, but the tension member is formed by heavy eye-bars connected by pins at the panel posts. At this point there is also suspended the floor timbers which, in turn, carry the girders for the support of the track. Such bridges are usually built with an open floor and have the ties resting upon the girders.

The third type, shown in Fig. 5, is a plate-girder bridge. It is extensively used in the United States especially for short spans. The girder is formed by riveting flat plates together with vertical rows of riveting. Such a union is usually effected by means of angle irons riveted to the ends of the sheets, which are in turn riveted together. The strength of such a bridge depends upon the shearing and tensile of the rivets at the bottom of the girder. The stress put upon these rivets depends upon the depth of the girder, the length of the span and the load. Horizontal buckling is prevented by diagonal and cross bracing between the two girders. The track is usually above the tops of the girders, though in some instances it is carried by a floor suspended from them.

We next come to five drawings that illustrate a few of the most notable railway bridges that have been built in the United States. Of these the first (Fig. 6) to be constructed was the suspension bridge over the gorge of the Niagara River below the falls for the Grand Trunk Ry. It has recently been supplanted by the arch bridge, Fig. 9. The original bridge was built in 1853-55, and was used until rebuilt in 1877. The rebuilding consisted of substituting iron towers for the stone ones first used, and an iron truss for the original wooden one.

This bridge is about two miles below the falls. The foundation over which the Niagara River flows, and through which it is supposed to have cut its way, from a short distance above Lewiston to where the falls now are, consists of nearly level strata of rock. These strata from the surface to a depth of about 180 ft., are principally of limestone. Underlying this portion is a bed of red sandstone about 40 ft. thick, or extending about to the surface of the water of the river. The gorge at the level of the surface of the rock is about 730 ft. wide, measured on the center line of the bridge. The surface of the rock of the Canadian side is about 10 ft. higher than that on the New York side.

The bridge was carried by four cables resting on the top of two iron towers at each end of the span, and having their ends anchored to the rocks. The length of the span between the centers of the towers was 821 ft. Two of these cables had a versed sine, at a mean temperature of 54 ft., and were called the upper cables. The other two cables had a versed sine of 64 ft. and were called the lower cables. The planes of the curves of the cables on each side were inclined so as to bring their lowest points nearer together than they are at the tops of the towers. From the tops of the towers to the anchorage the cables diverged from the center line sufficiently to make their pressure upon the towers vertical. The portions of the cable on each side of the tower and adjacent to it formed the same angle with the vertical. Hence the anchorage of the upper cable was about 37 ft. further from the tower than that of the lower cable.

The suspended structure consisted of two floors, one above the other, connected together at each

side by posts and truss rods, the latter inclining each way in such a manner as to form a trussed tube. The object of the trusses was not to aid in supporting the load, but to prevent excessive undulation. The upper floor was secured to the upper cables by means of wire suspenders, and it carried the railroad track. The lower floor was, in the same manner, secured to the lower cable and formed the foot and carriage way. The structure was secured against lateral vibrations by means of wire-rope guys from each side of the lower floor to rocks on each bank of the river.

Each cable was composed of 3,640 iron wires, of scant No. 9, Birmingham gage. They were first laid in seven separate strands or bundles of straight wire made continuous by splicing. After the seven strands were completed and adjusted, they were served closely with wire throughout their length, with the exception of those portions on the top of the tower, and about 13 ft. of their length at each end, thus forming one cylindrical bundle 10¼ ins. in diameter.

In order to form the anchorages, pits were sunk into the rock to a depth of 25 ft., which were enlarged at the bottom for the reception of heavy cast-iron anchor plates. The chains entered the rock vertically and passed downward to the plate where the lower end of each bottom link passed through a separate hole cored through the plate, and was secured by a pin passing through the head of the links and resting in concave seats in the lower edge of the partitions. The plates and chains were then built in solidly with blocks of stone cut to fit each place and thoroughly grouted so as to exclude water from the iron.

On the top of the tower there was a heavy iron plate bedded in cement and covering a surface 8 ft. square. The upper surface of the plate had three ribs cast upon it parallel to the line of the cables. The two clear spaces between these ribs were each 2 ft. wide. Each groove had a set of turned iron rollers 5 ins. in diameter, lying close together and at right angles to the ribs. Each set of rollers supported a cast-iron saddle, whose underside was planed to rest on the rollers. The upperside of the saddle had a groove of semicircular section in which the cables lay.

As already stated there were 3,640 wires in each cable. The average ultimated strength of each wire was 1,648 lbs., giving for the strength of one cable 3,000 tons, or for the four cables 12,000 tons, in the direction of their length. The suspended weight of the bridge between the tower, including the cables, stays, etc., was 1,050 tons. With the maximum live load of 350 tons, making 1,400 tons in all, there was a factor of safety of 4.41. The maximum load on the top of one tower was 700 tons, and this, at first carried by the stone tower, was afterwards supported by the four legs of the iron tower, as shown in the drawing.

The second of this series, Fig. 7, is probably one of the best known bridges of the world. It is the celebrated Eads Bridge crossing the Mississippi River at St. Louis, Mo. It was the first of the great bridges that have been built across this stream, and, at the time of its construction, it attracted world-wide attention. It consists of three spans, each formed of four ribbed arches made of cast steel. The center span is 515 ft. and the side ones 47 ft. 10 ins. each.
of the center one is one-tenth of the span, that of the side ones 47 ft. 10 ins. each.

Each of the four arches forming each of these spans consist of an upper and lower curved member or rib extending from pier to pier. Each of these members consists of two parallel steel tubes, 9 ins. in exterior diameter, placed side by side. The upper and lower members are 8 ft. apart, measured from the center of the upper to the center of the lower tubes. At regular intervals of about 9 ft. these members are braced from each other by a vertical system at each end to cast-steel plates formed something like the voussoirs of a stone arch, and against which the tubes are abutted and secured every 9 ft. throughout the arches. A horizontal system of bracing extends from pier to pier between the four curved members, and a similar system between the four lower ones, for the purpose of securing the four arches in their distances from each other and to sustain them against lateral pressure.

The two center arches of each span are 13 ft. 9½ ins. apart c. to c., and have, in addition to the upper and lower horizontal bracing just described, a system of diagonal bracing, securing the upper member of one arch to the lower one of the other arch, and the two other members in like manner. The outside arches are each 15 ft. 1¾ ins. from the middle ones, and are joined to the latter by three systems of bracings similar to those described as between the two center arches. These systems, however, on the outside of the middle arches, extend only from the pier to the underside of the railways, the latter being carried between the two outer and the two inner near their crowns. The outside arches being supported in this interval against lateral movement by rigid connections from both the upper and lower roadways.

The roadways are formed by transverse iron beams, 12 ins. in depth, supported by iron struts of cruciform section resting on the arches at the points where the vertical bracing of the latter is secured. That portion of the railways which passes below the crown of the arches is suspended from them. Between the iron beams forming the roadways, four parallel systems of longitudinal wooden members are introduced, extending from pier to pier, and serve to maintain the iron beams in position. These wooden members are each about 9 ft. long, and their ends rest upon the flanges of the beams and are secured from moving. On these the wooden beams for the carriageway rest in one roadway, and the cross-ties for the railways in the other. From the opposite ends of the iron beams a double system of diagonal horizontal iron bracing serves to bind the whole together, and gives additional support against wind pressure.

The upper roadway is 34 ft. wide between the footwalks. The latter are each 8 ft. wide, making the bridge 50 ft. wide between the railings. The railway passages below the carriage way are each 13 ft. 6 ins. in the clear and 18 ft. high, and extend through arched openings of equal size in the abutments and piers. The railways are carried over the wharves on each side of the river on five stone arches, each 26 ft. wide, and are enclosed throughout this distance by a cut-stone arcade of 20 arches supporting the upper roadway.

The arches have been designed with sufficient strength to sustain the greatest number of people that can stand together upon the carriageway and footpaths from end to end of the bridge, and, at the same time, have each railway track below covered from end to end with locomotives. With this enormous load the strength of the arches will be taxed to the extent of less than one-sixth of the ultimate strength of the steel of which they have been constructed. The piers and abutments have been designed with a view to sustain either span when thus loaded, even if the other were entirely unloaded, and to sustain either span if from any cause the adjoining ones should be destroyed. The arches have also been designed to resist the effects of any portion of the span being loaded, as above stated, with any other portion of the same span entirely unloaded.

It will be seen, therefore, that the bridge has been designed to sustain a greater load than will ever be placed upon it. No occasion can possibly occur requiring it to be densely packed with human beings on the upper roadway, and at the same time have its railways covered with locomotives below. Yet the ultimate strength of the materials of which it is composed is such that the three arches are capable of sustaining 28,972 tons before they would give way under it. The work of construction was begun August 20, 1867, and was completed in the latter part of June, 1874.

After the completion of the Eads Bridge the next one to attract general attention was the cantilever bridge of the Michigan Central R. R. across the gorge of the Niagara River just above the old suspension bridge. It was notable for the rapidity with which it was constructed and also from the fact that, at the time of its erection (1884), it was the largest cantilever railway bridge in the world. It will be seen that, in this instance, the cantilever is peculiarly well adapted to the site, giving, as it does, excellent facilities for erection by building out panel by panel over the strong current which renders any feasible falsework under the center span out of the question.

The bridge consists of two steel towers or piers, each supporting a girder near its center, the shore ends of these being anchored down to abutments, and the ends projecting over the river supporting a separate intermediate girder spanning the gap between the main girders, which are termed "cantilevers," from their projecting out on each side of their support. The whole bridge is thus formed of three girders which are attached to one another and to the abutments by links, in such a manner that expansion and contraction due to varying temperature is permitted to each member, while laterally a sliding joint is formed which prevents any part of the bridge being displaced sideways by the effect of such wind pressure as may be brought against it.

The center girder is supported from the outer end of the river arms of the cantilever by links, which form the sole vertical connection between the cantilever and the center girder. Either therefore is free to expand or contract or assume an angle with the other in a vertical plane, and consequently this arrangement permits both the longitudinal expansion of the bridge, and any unequal expansion of the two steel piers, without throwing any undue strains on the structure.

The lateral continuity, giving strength to resist wind pressure, is obtained as follows: the pin or the lower end of the link suspending the center truss, is connected by horizontal slotted bars to the end of the centilever. This connection permits a relative horizontal or vertical movement, but as the links slide in contact with the sides of the bottom chord of the center girder, and are braced by wind ties, any lateral motion is impossible. The wind ties of the center girder are brought up to the end pin, and the short distance between the two systems of wind ties prevent any serious cross-breaking strain being brought on the horizontal slotted connecting link. Taken laterally, then, the center slides between guides firmly attached to the cantilevers, and it is evident that before the wind can blow the center girder sideways, either these guides must be sheared or the wind bracing give way.

The shore arm is held down by links connected to a heavy-weighted abutment, which counteracts the tendency of the shore arm to rise when the center girder is heavily laden. The general dimensions of the bridge are as follows:

| | |
|---|---|
| Length over all c. to c. of end pins | 910 ft. 1⅝ ins. |
| Center portion | 119 " 9 " |
| Each cantilever | 395 " 2¼ " |
| Weight of wrought iron towers | 150 " 6½ " |
| Of masonry piers | 36 ft. |
| Depth of beton foundation | 8 " |
| Length of panels, cantilevers | 25 " |
| Of panels, center girder | 24 " |
| Trusses apart between centers | 28 " |
| Depth of cantilever trusses, over tower | 56 " |
| " " river ends | 26 " |
| " " shore ends | 21 " |
| Depth of floor beams | 4 " |
| Longitudinal stringer | 2 ft. 6 ins. |
| Ties, white oak, 18 ins. apart | 9 × 9 " |
| Guard timbers, white oak | 8 × 8 " |

The total quantity of materials used in the bridge and towers, exclusive of the approaches, is as follows:

| | |
|---|---|
| Steel, lbs. | 1,272,000 |
| Wrought iron lbs. | 3,093,000 |
| Cast iron, lbs. | 126,000 |
| Total, lbs. | 4,491,000 |
| Timber in floor, ft. B. M., | 154,000 |
| Beton in foundations, cu. ft. | 31,000 |
| Masonry in piers, cu. yds. | 2,800 |
| Masonry in anchorage piers, cu. yds. | 900 |

The materials used in the superstructure is open-hearth steel and wrought iron. Towers and heavy compression members, such as lower chords and center posts, are of steel, as are all the pins. All tension members are wrought iron. The only use made of cast iron is the pedestals on the masonry and in filling-rings; the castings at the top of the towers are all of steel.

The increase in the weight of the locomotives and cars that railway bridges have been called upon to carry of recent years, necessitated either the replacing or the reconstruction of the suspension bridge at Niagara. The former course was decided upon, and in 1896 work was commenced on the arch bridge, illustrated by Fig. 9, the work having been completed in 1897. Like the suspension bridge which it replaced it serves to carry

the tracks of the Grand Trunk Ry. in addition to carriageways and footpaths. It occupies the old site and was erected without causing any suspension of traffic.

This bridge is known as a two-hinged spandrel-braced arch. The trusses have a horizontal top chord and a parabolic rib. They are battered one in ten. The skewbacks of the arch are located on a solid stratum of limestone from 12 ft. to 14 ft. in thickness about half way between the water and the top of the bluff. The skewback masonry is limestone, with granite copings, entirely of dimensions stones with ½-in. joints and a strong bond.

The end bearing consists of two steel castings having, between the concave face of the lower and the convex face of the upper, a nest of 45 segmental rollers set radially with respect to the center movement at the pin. This form of bearing reduces the frictional resistance much as a ball bearing does, and was adopted to avoid the use of an excessively large pin, with which movement is rather doubtful of realization. The bearing on the rollers, with a maximum load on the bridge, is 2,200 lbs. per lin. in. of roller, assuming the pressure to be uniform on all the rollers.

The bridge was calculated to sustain a load of 10,000 lbs. per running foot. In making the test of the structure two trains were used. Each consisted of two heavy pushing locomotives, four other heavy locomotives and nine coal cars. The cars had a capacity of 30 tons, were loaded with coal and had as many rails piled on top as was deemed safe for the cars. With the load extending from the center of the bridge to the shore the maximum deflection was ⅞-in. at one-quarter the length of the span from the shore. With the load reaching the whole length of the span the maximum deflection was at the center and was 13-16-in. at that point.

The last drawing of the series illustrates the most recent bridge that has been built across the Mississippi River, and one that was fully described in Engineering News of Jan. 11 of the current year. It is the bridge that has been built at Rock Island, Ill., crossing to Clinton, Ia.

This structure is made up of seven spans with a draw span over the main channel, its total length being 2,310 ft. Commencing at the Rock Island side, from which the accompanying illustration was taken, the bridge consists first of three spans of 200 ft., then a draw span 442 ft. between the end pins, followed by four fixed spans, the first is 265 ft. in length and the others are each 300 ft. in length. The total length of the viaduct approaches is 850 ft., the spans of which vary from 30 to 70 ft. in length. The superstructure is of the standard American type throughout, with built-up lattice, posts and chords, and eye-bars for the tension members. The bridge is carried upon masonry piers, the foundations of which were carried down by the pneumatic process. The draw span is electrically operated.

As the pivot pier of the draw span is exposed to floods and to a heavy flow of ice it is protected by a fender pier on the upstream side. This pier is a continuous timber crib 26 ft. in width, 250 ft. long, and 28 ft. in height, the water at this point being 7 ft. deep at its lowest stage. The crib is strengthened by four interior longitudinal walls and by a series of transverse walls spaced 8 ft. from center to center. The nose of the crib at its upstream end is formed with an angle of 90°.

To protect the cutting edge at the nose from heavy floating drift wood and the section of ice, it is sheathed with a protection of old rails. The rails which weigh 65 lbs. to the yard were laid up the face of the slope in 28-ft. lengths. They were spaced 5 ins. apart c. to c. and were fastened with ordinary railway spikes to each horizontal course of cribwork. They were also secured by drift bolts which passed through holes in each side of the flanges, and were secured by nuts on the inner side of the timbers of the cribwork. After the rails were all in place the intervening spaces were filled up with cement mortar so as to afford a practically smooth surface and avoid any roughness which would tend to cause a lodgment of driftwood or ice against the nose.

## PROGRESS TOWARDS UNIFORM MUNICIPAL STATISTICS IN THE UNITED STATES.

In our issue of June 14 we called attention to the need and advantages of uniformity in municipal accounts, laying particular emphasis on the fact that such uniformity is a prerequisite to the collection of satisfactory municipal statistics, now being promoted by committees of the American Society of Civil Engineers, the American Society of Municipal Improvements, and other organizations whose members are interested in municipal work. We outlined briefly some of the steps already taken to secure uniformity in both municipal accounts and reports, and promised to give details of this action in a later issue. In the review that follows no claim for completeness is made, but it is believed that the most significant attempts in this line thus far made in the United States are included.

The work thus far accomplished in the United States in the way of uniform municipal accounts and reports has proceeded along three main lines: (1) State supervision of accounts, sometimes involving State audit, and in one or two instances, at least, including annual reports to a State officer on forms prescribed by him. (2) State administrative control of certain local interests or industries, such as street railways, lighting plants, sewerage systems, water-works, vital statistics, assessment and taxation and public schools. (3) Voluntary action by organizations devoted to some branch of municipal activity, such as water and lighting plants, pavements and sewers, street railways and municipal laboratories. Much of the work done by these organizations has gone no further than the mere adoption of schedules, and often these have fallen to the ground by their own weight, through over-elaborateness, or else because of the apathy of the members, or the lack of proper men or funds to carry out the desired reforms. There has been one notable exception in evidence for a dozen years, and some promising new moves are now being made.

### State Supervision of Municipal Accounts.

The principal successful attempts to secure State control of municipal accounts (other than county) in this country seem to have been in Wyoming, Virginia and Indiana, where certain classes of municipalities are required by law to report annually to the State Auditor, or some like official.* In Alabama, Kansas, Massachusetts, Minnesota, New York, North Dakota and South Dakota, according to Prof. J. W. Jenks (see foot-note), State Examiners or similar officers were in existence in 1898, with more or less control over county accounts. Some or all of these officials control State accounts as well, all of which shows that the movement towards the State supervision of accounts is well under way.

The office of State Examiner was established in Wyoming by the Legislature of 1890-1 (Session Laws, Chap. 84). Besides the supervision of the State institutions and private companies engaged in banking and loan operations, his jurisdiction extends over county, city and town officials, including school districts. According to an excellent summary given in Professor Tooke's article (see list of references in foot note):

> The state examiner is empowered and it is his duty to exercise a constant supervision over the books and financial accounts of the municipal corporations of the state. He is required to order and enforce a correct and, as far as practicable, uniform system of bookkeeping by state, county and municipal officers, so as to afford a suitable check on their action, and to insure the safety and a thorough supervision of the funds of the state and of the counties and other municipal corporations. He has full power to expose false or erroneous systems of accounting, and, when he deems it necessary, to instruct the local officers in the proper methods of keeping their accounts. He may require, from time to time, complete and verified statements of their accounts, and must visit each year, at irregular intervals and without notice, the county officers, and make a thorough examination of the books, accounts and vouchers of such officers. He must, upon request of the city council of any municipality, make a like examination of the accounts of the city and report in the first instance to the council.
>
> In order that these powers may be fully exercised, he may issue subpoenas and administer oaths in the same manner and with the same power to enforce obedience thereof as belongs to the courts of law of the state. Any officer refusing or neglecting to make the required returns, under oath, is to be deemed guilty of felony and to be punished by a fine not less than $1,000 and not exceeding $5,000, or by imprisonment in the penitentiary not less than one year nor more than five years, or both. Any person making an exhibit, or giving information required, or making any statement under the act, upon oath, who shall knowingly swear falsely concerning the same, is to be deemed guilty of perjury. Any person who shall wilfully obstruct or mislead the state examiner in the execution of his duties is guilty of felony and punishable as are officers refusing to make the required returns.
>
> In the enforcement of these provisions the examiner reports to the attorney-general, or to the prosecuting attorney of the county, the refusal or neglect of county officers to obey instructions, and such officers must take prompt steps to enforce a compliance on the part of local officials. Further, the examiner may report to the governor at any time any failure of duty of any public official under the supervision. The governor thereupon may, if he thinks the public interest requires such action, suspend such officer from further performance of duty, until a more complete examination can be held or such security obtained as may be demanded for the prompt protection of the public funds. In the case of the discovery of any defalcation in the office of the treasurer of county, city or school district, the examiner is authorized to take immediate control of the office, funds, books and accounts of such officer, and to act as treasurer until such time as the officer accused may be reinstated or finally removed and his successor appointed.
>
> In carrying out the duties of the office, the examiner passes upon every account paid by the order of the county commissioner, to determine whether it is prepared in compliance with the statute, and personally vouches for the form of all bonds given by municipal officers. In general, his supervision extends directly to every account of the counties and indirectly to all the financial operations of other municipal corporations.

Provision for an Examiner of Public Accounts was made in Louisiana in 1892 (Session Laws, Chap. 72). The act authorized the Governor to require this officer to investigate the affairs of any parish. No appropriations were made for carrying out the provisions of this act, and it was repealed in 1894.

The Virginia legislature of 1898 (Session Laws, Chap. 895) passed an act providing that city and county treasurers must report annually all receipts and expenditures to the auditor of public accounts, according to forms prescribed by him, and that he should publish an abstract of these reports.

A recent Indiana statute (March 3, 1899),

> provides for the use, by all the township trustees of the state, of a common schedule to be prepared and enforced by the State auditor. The county law of the same date practically secures the same result for the counties by providing for a more systematic preparation of their budgets.*

Two attempts, thus far unsuccessful, have been made to establish a comprehensive municipal government board for the State of New York. Their failure, it is believed, has been largely due to a misunderstanding of their intent, and to the fact that all reforms of this sort generally require a number of years of agitation before they are adopted. The New York bill was the outcome of the work of two State commissions appointed by the Governor under an act of 1895 to prepare uniform charters for cities of the second and third classes, respectively. The commissions reported separate charter acts, but united in recommending an act providing for a municipal government board to have the general supervision of cities of the second and third classes (all cities in the State except Greater New York and Buffalo). The board would prescribe uniform systems of accounting and reports for every municipal department, besides having power to investigate the affairs of municipalities with the aid of experts. Numerous other provisions were included in the bill, all designed to

*The following references to the literature of this subject and the broader one of State Boards of Municipal Control, both here and abroad, will enable those interested to pursue the subject further:

"State Supervision for Cities," by Prof. John R. Commons. "Annals American Academy of Political Science, vol. V., p. 37 (1895).

"State Boards of Municipal Control," by Fred'k Wm. Holls, Proc. National Municipal League, 1896.

"Municipal Statistical Offices in Europe," by Dr. Edw. M. Hartwell, City Doc. No. 94 (1897), Boston, Mass.; also, in part, in "Municipal Affairs" for Sept., 1897.

"Uniformity in Municipal Finance," by Prof. C. W. Tooke; and "A State Municipal Board," by Prof. J. W. Jenks. "Municipal Affairs" for June and September, 1898, respectively.

"Public Accounting Under the Proposed Municipal Program," by Prof. L. S. Rowe, and a number of other papers on municipal accounting, Proc. National Municipal League, 1899; also (Professor Rowe's paper) in "A Municipal Program," The Macmillan Co.

"English Local Government of To-Day, a Study in the Relations of Central and Local Government," by Milo Roy Maltbie; "The Centralization of Administration in New York State," by John A. Fairlie; and "Public Administration in Massachusetts," by Robt. H. Whitten; Columbia University Publications, 1897 and 1898.

Besides these special papers and books reference may be made with profit to Prof. Frank J. Goodnow's "Municipal Problems and Municipal Home Rule," and Dr. Albert Shaw's "Municipal Government in Great Britain" and "Municipal Government on the Continent of Europe."

*"The Importance of Uniformity for Purposes of Comparison." Dr. Samuel E. Sprarling, Proc. National Municipal League, 1899.

secure better municipal government (see references, in foot-note, to articles by Messrs. Hollis and Jenks).

Another attempt to secure uniform accounts throughout a State is included in "The Revised Municipal Code of Ohio," prepared by a commission last year and submitted to the Legislature of 1900. The whole code failed of adoption, as we understand it, but very likely it will be brought before the legislature again. The code contained provisions relating to municipal accounting almost identical with those in the "Municipal Program" of The National Municipal League, given near the close of this article.

This division of our review may be closed by a mention of the efforts to secure uniform State legislation throughout the country. This effort, we believe, has been directed more particularly to such subjects as marriage, divorce, insurance and other corporation laws, but all organized efforts having uniformity as their object contribute to the same general end.

State Administrative Control of Single Classes of Municipal Service Through Commissions.

The provisions for State control just reviewed relate chiefly to uniform accounting for municipalities as a whole. Far more has been accomplished by State commissions or boards devoted to only one line of municipal activity. These will be considered next.

No single class of municipal records is of more importance than vital statistics. This is so widely recognized that, according to Mr. Robert H. Whitten.*

Some provision for a general registration of vital statistics is now made by statute in all but 14 States, though the law in many cases is wholly or partially inoperative.*

Ten States "have maintained a fairly complete system" of "collection and publication of their vital statistics" for periods ranging from 57 to 2 years. These States, arranged both in chronological and geographical order, are as follows:†

| | | | |
|---|---|---|---|
| Massachusetts | 1842 | Maine | 1892 |
| Connecticut | 1848 | New Hampshire | 1880 |
| Rhode Island | 1853 | Vermont | 1857 |
| Vermont | 1857 | Massachusetts | 1842 |
| New Jersey | 1878 | Rhode Island | 1853 |
| New Hampshire | 1890 | Connecticut | 1848 |
| Delaware | 1881 | New York | 1893 |
| Maine | 1892 | New Jersey | 1878 |
| New York | 1893 | Delaware | 1881 |
| ‡Michigan | 1897 | ‡Michigan | 1897 |

In many States which have a partial or no system of State registration of vital statistics, individual cities and towns are doing work ranging all the way from mediocre to excellent. Even where the work is voluntary and isolated it possesses many elements of uniformity with all other statistical records of this class, not only within the particular State in question, but throughout this country, and, to a lesser degree, throughout the world. This is partly due to the nature of the statistics themselves and largely to the great influence exercised by some of the leading statisticians, particularly Farr and Bertillon.

Closely akin to the registration of vital statistics is some of the work done by State Boards of Health. Such boards now exist, in various degrees of efficiency, in all but five States (Georgia, Idaho, Montana, Oregon and Wyoming, according to Mr. Whitten).

The chief work of these boards tending to uniformity of statistics within the several States, aside from that related to vital statistics, is due to the excellent laboratories, maintained by a few of them for the chemical, bacterial, and, more rarely, the microscopical analysis of water. In addition, several of these laboratories make regular analyses of sewage, in order to show what is being accomplished by sewage purification works. Massachusetts has led the way in this, as in so many other lines of modern work. For a dozen years or so it has made periodic analyses, often monthly, of water from the various public supplies of the State. It has gradually extended the same class of work to sewage purification works, collecting and presenting other information than analyses regarding these plants. It has also collected general statistical information regarding water-works, but in the line of uniform water and sewerage statistics its positive control extends little if any beyond its own laboratory. Vermont, Rhode Island, Connecticut, Delaware, Maryland and Ohio are also analyzing water from public supplies, and doing more or less in the way of general studies of stream pollution, but their work is far less extensive than that of Massachusetts.

Perhaps the oldest class of comparative municipal statistics available in this country are those relating to the public schools. State school funds have been distributed on the basis of school attendance for scores of years, and attempts have been made to secure uniform returns of children of school age, school attendance and various other particulars relating to schools. At present, every State in the Union has some form of central control over schools. Since 1867 we have had a national bureau of education, charged particularly with the collection of "such statistics and facts as shall show the condition and progress of education in the several States and Territories." Mention may also be made of the returns of assessed valuations and rates of taxation made in many States.

A body similar in some respects to boards of health is the State Sewerage Commission of New Jersey. So far as we know, this is the only board authorized by law to require periodic reports from municipalities regarding their sewerage systems. The board was created in 1899, but is now working under a revised statute, passed this year (Session Laws of 1900, Chap. 72). Sec. 10 of this act is as follows:

On or before Jan. 1, 1900, and thereafter, whenever required by said commission, the mayor of every municipality, and the chairman of every township committee of every township now having, using, owning, leasing or controlling a sewerage plant or system, shall furnish to said commission on blanks to be provided by said commission, a statement showing the disposition made of the sewage of their respective municipalities or townships, and as near as possible the amount discharged each 24 hours, and such other information and data as may be called for by said blanks, to be provided as aforesaid by said commission.

The commission submitted its first report, including returns relating to the sewerage systems of the State, to the New Jersey legislature of 1900.

State Highway Commissions, although having little or no control over records other than their own, are bringing together a rapidly-increasing amount of valuable statistical information relating to the construction of macadam, telford and gravel roads. Massachusetts and New Jersey have led in State road improvements in rural and suburban districts; Connecticut has been giving State aid for a number of years, and New York has just begun. Rhode Island tried the plan for awhile, but abandoned it in 1899. A number of other States have established or appear to be moving towards State highway commissions and State aid, but with these, as with the majority of the commonwealths giving State aid, the contribution towards uniform statistics is more a promise for the future than an actual accomplishment. In reporting on the State roads actually built the various commissions in charge give such leading facts as the character of the improvement, its width, depth and cost, and sometimes other figures of value. Massachusetts ranks first in the range and completeness of its highway statistics, and although these seem to relate wholly to the work done under its direction, the commission has had full authority from the start to collect general statistics relating to roads and streets. The act of 1892 (Chap. 338), establishing the commission, provided that county, city and town officers should, on request, give the State commissioners

any information required by them concerning the public ways, roads or bridges within their jurisdiction,

while in 1893 an act (Chap. 476) enlarging the scope of the commission, stated that it should

from time to time compile statistics relating to the public roads of cities, towns and counties, and make such investigations relating thereto as they (it) shall deem expedient,

at the same time renewing the clause first quoted. The statistics published by the Massachusetts Highway Commission are unequalled in this country. They show, among other things, the physical characteristics of the improvements made under its direction, their cost, the character and cost of the maintenance of State roads, and the results of a long series of laboratory tests on stones used or proposed for use in highway construction throughout the State. Perhaps if the other State commissions had been as amply equipped with funds and legislative powers they would not have lagged so far behind Massachusetts in their statistical work, but it is only fair to Massachusetts to say that the personnel of its commission would have ensured valuable results under the most adverse circumstances.*

Still more unique, in some respects, than the Highway Commission and State Board of Health of Massachusetts is its Gas & Electric Light Commission, the only body of the sort on this continent. This commission has recently issued its fifteenth annual report, a volume containing, like its predecessors, a wide range of statistical and descriptive matter regarding each of the gas and electric lighting plants of the State, whether under private or public ownership. When the commission was established its jurisdiction extended to gas plants only, but in 1887 it was given the same power over electric lighting plants, and its authority has been extended from time to time since. It prescribes the forms to be used by the various works in keeping accounts and in making reports of the commission. Comments on certain phases of the last report of this board were made in our issue of June 21, 1900.

Another class of municipal service covered by State commissions is street railways. The railway commissions of Maine, Massachusetts, Connecticut and New York collect quite extensive statistics regarding the street railways of their several States, the details of operation being particularly full. The Rhode Island and North Carolina commissions make less complete exhibits. The Illinois commission gives pretty full returns for lines in Chicago. The Vermont commission has had control of electric street railways since 1898. Perhaps some other States should be included in the list. The commissions for the first four States named publish quite a number of items identical in character, or readily comparable. The last report of the Connecticut commission includes a schedule, adopted by several voluntary organizations, designed to secure uniform accounting in the various States. This schedule has already been adopted by the Connecticut commission, for use by all the street railways of that State after June 30, 1900.

Among the various investigations undertaken by State Bureaus of Labor Statistics some have been more or less closely related to municipal questions, and have tended or will tend towards uniformity. Probably the bulk of this work, however, has done more to show the need of uniform municipal statistics than to bring them into existence. Notable among the inquiries attempted by these boards has been one carried out in many States to determine the relative advantages of municipal and private ownership of water-works and lighting plants. The results in some States have been published in the annual reports of the corresponding boards. The inquiry has been supplemented by the U. S. Department of Labor, and it is understood that an exhibit covering the whole United States will be issued from Washington at an early date.

Another important undertaking by the U. S. Department of Labor is the collection of statistics of cities having a population of 30,000 and upwards, noted in the discussion on uniform accounting in our issue of June 14, 1900. Like the investigation of municipal ownership, this undertaking has also shown the deplorable lack of uniformity in municipal accounts and reports.

There are two classes of records, which, while not strictly municipal, are sometimes kept by cities and towns, and are very essential to the design and operation of some of the most important municipal works. These are meteorological statistics and stream gagings. Through our National and State weather bureaus uniform meteorologi-

*"Trend of Legislation in the United States," by Robert Harvey Whitten, Ph.D., Sociology Librarian, University of the State of New York. State Library Bulletin, Legislation, No. 12, May, 1900.

†"The Past and Present Conditions of Public Hygiene and State Medicine in the United States." By Samuel W. Abbott, Secretary of the Massachusetts State Board of Health. Monograph XIX., American Social Economics, Dept. of Social Economy for the U. S. Com. to the Paris Exposition. H. B. Adams, Editor.

‡Michigan, Minnesota, Indiana, Kentucky and Alabama have had "a partially complete collection of marriages, births and deaths for several (a number of?—Ed.) years."

*Reports have been made by the Commissioner of Public Roads of New Jersey each year, beginning with 1894, when State aid was first given. The Connecticut Highway Commission began its work in 1895, and has reported on each year's work since, but as two years' reports are published together, the report for 1899 is not available. Reports for the Vermont Highway Commission were issued in 1894 and 1896, but contained only a few statistics.

cal records are being kept in many cities distributed over the whole country. The hydrographical department of the U. S. Geological Survey and departments of some of our States are making periodic stream gagings at various widely-distributed points. In addition to National and State work in these two lines many cities have maintained meteorological and stream gaging stations for years past, thus adding to the records available for comparative purposes.

The Work of Voluntary National Organizations

What appears to be the most promising recent attempt to secure interstate uniformity in any branch of municipal statistics has already been mentioned in connection with street railway returns to the Connecticut Railroad Commission. According to the last report of that body a committee to devise a uniform system of street railway accounts and reports was appointed in May, 1897, by the National Convention of Railroad Commissioners, which met jointly with the Interstate Commerce Commission at St. Louis. Without going into the details of the succeeding steps, it may be stated that at the meeting of the same association, held in Denver, in August, 1899, the committee in question submitted a report which in the meantime had been devised and adopted by the Street Railway Accountants' Association of America, and had also been approved by the Association of American Railway Accounting Officers. This report was adopted by the Denver convention, so that it now has the sanction of three separate voluntary national organizations, one made up of State officials, and the other two drawing its membership from street railway and general railway accountants, respectively. The schedule in question occupies 77 pages of the report of the Connecticut Railroad Commission for 1899. Its scope is partly indicated by its title:

A Standard System of Street Railway Accounting, Covering the Classification of Construction and Equipment Accounts, Classification of Operating Expense Accounts, and Forms of Monthly and Annual Reports.

As has been stated, this standard system has been prescribed by the Connecticut Railroad Commission for all the street railways of that State. If it is as admirable a system of accounts and reports as is indicated by its origin and by a hasty examination of its details, it is to be hoped that it will be adopted by all the other State railroad commissions.

The earliest achievement by a voluntary organization in securing the adoption by its members of a system of uniform municipal reports, so far as we can learn, falls to the credit of the New England Water-Works Association, a body with greater geographical breadth than is implied by its name. In June, 1885, this association adopted a scheme for the statistical portion of the annual reports of water departments, as submitted by a committee consisting of Messrs. Wm. R. Billings and R. C. P. Coggeshall. This schedule is a model of its kind, not being so ambitious as to defeat its object through over-elaborateness, but yet presenting a comprehensive summary of the character of the works in question, and their operation during the year, and at the same time going into detail in a few essential particulars. Just how many works have adopted this form we cannot say, but the number has been sufficient to warrant the tabulation of the chief items by cities, and the presentation of the results from time to time in the Journal of the New England Water-Works' Association. In this way, comparative figures have been given for the years 1886 to 1896, inclusive. The greatest number of cities represented in any one table has been 23. This figure, it is true, was only a small percentage of the membership of the association, and a far smaller percentage of all the water-works in the country.

A month or two before the adoption of this report by the New England Water-Works Association, a similar committee, consisting of Messrs. J. J. R. Croes, M. Am. Soc. C. E., and Chas G. Price, submitted a brief outline for a uniform system of annual reports to the American Water-Works Association. No action on the report seems to have been taken by the convention further than to order it printed with the proceedings, and it appears that the good work done by the committee stopped when it submitted its report, although the form may have been used awhile by a few works.

About 1890, the Western Gas Association perfected a form for reporting on gas operations up to gas in the holder, but it appears that nothing further came of the action. At the meeting of the same association a few weeks ago, Mr. W. E. Steinwedell, of Belleville, Ill., presented a paper entitled a "Monthly Technical Report of Operations in Coal Gas Works," which included a schedule for uniform reports. Later on, a motion looking to the securing of uniform reports was unfavorably received.

At the last meeting of the National Electric Light Association, held at Chicago a few weeks ago, Mr. Jas. B. Cahoon, of Syracuse, N. Y., submitted detailed forms for uniform gas and electric lighting accounts. The convention voted to have a committee prepare a system of uniform accounting, to be presented at the next annual meeting.*

In 1898, the Committee on Municipal Data, consisting of Messrs. Chas. C. Brown, Bloomington, Ill., Lansing H. Beach, Washington, D. C., and A. D. Thompson, Peoria, Ill., submitted to the American Society of Municipal Improvements three forms for making up annual reports on waterworks, sewerage and street paving, respectively. In 1899, the same forms were again submitted to the society, having been under consideration by the committee during the intervening year. It does not appear that the forms were adopted by the society at either meeting. So far as the committee knew, no members had used the forms in making up annual reports, and, more discouraging still, although the committee had urgently requested members to criticise the forms none had done so during the year. The committee was continued for another year, Mr. Brown remaining in service, but Messrs. L. E. Farnham, of Camden, N. J., and David Hunter, Jr., of Allegheny, Pa., being substituted for the other two original members.

Uniform laboratory methods and results would be of great advantage to engineers and others engaged in municipal work. In 1895, the National Brick Manufacturers' Association inaugurated an "investigation of the methods employed in testing paving brick, with a view to establishing some standard method if possible."†

A committee of seven was appointed to carry on this work. The committee chose Mr. D. W. Mead, M. Am. Soc. C. E., now of Chicago, as chairman, and Prof. Edw. Orton, Jr., of Columbus, O., as secretary. It submitted its final report to the association at the meeting held in February, 1897. The report, as adopted by the association, is printed in the proceedings of the latter for 1897.

Of more general interest to engineers than the standard for paving brick tests is uniformity in methods of testing cement, a subject which has been under investigation for two years by a committee of the American Society of Civil Engineers. A progress report of this committee was reviewed editorially in our issue of June 21, 1900. Cement now enters so extensively into various classes of municipal work that uniform methods of making and reporting the tests would be very advantageous.

Still another class of laboratory work where uniformity is highly desirable is water analysis. The American Public Health Association now has a Committee on Standard Methods of Water Analysis, with Mr. Geo. W. Fuller, Assoc. M. Am. Soc. C. E., of New York, as chairman, and Mr. Geo. C. Whipple, Assoc. M. Am. Soc. C. E., as secretary. The committee was appointed last November. Presumably, it will report at the coming meeting at Indianapolis, Oct. 1 to 5.

The American Public Health Association also deserves great credit for its endeavors to improve the classification of vital statistics. In 1893, the system of Dr. Bertillon, of Paris, was brought to the attention of the American public by means of a paper by Dr. Bertillon, read before the International Statistical Association, at Chicago. The subject was taken up, the same year, by the American Public Health Association, and after subsequent committee work, it was endorsed by the association in October, 1898. Dr. S. W. Abbott states, in his monograph, previously cited, that:

This committee, through the commendable activity of its secretary, Dr. Wilbur, has accomplished much toward the introduction of the system in several of the registration States, and in some of the larger cities. A very full and complete presentation of the system, with minor details and adaptations to an American population, was printed in the monthly bulletin of vital statistics of Michigan, beginning with February, 1898.

In August, 1898, the League of American Municipalities adopted resolutions strongly in favor of uniform municipal accounting throughout each State, a State audit for the accounts of both municipalities and of private corporations, rendering municipal service, the publication of comparative statements "showing the results of municipal administration" and accounts "designed to show the entire and true costs of all public utilities operated by any municipality or private corporation."

In December, 1898, a committee of the National Municipal League reported to that body a "Municipal Program" containing admirable provisions relating to municipal accounting along much the same line as the resolutions noted just above, but in definite shape for incorporation in State constitutions and municipal charters. This Program, after being referred back to the committee, was again reported to the National Municipal League in November, 1899, and adopted, including the provisions in question. These required every city to make financial reports at least yearly to some State official,

in accordance with forms and methods prescribed by him, which shall be applicable to all cities within the State; such reports shall be printed as a part of the public documents of the State.

The contents of these reports is specified in outline. The State official to whom they are made would not have the power of general audit, but would be authorized "to examine into the affairs of the financial department of any city within the State." The "Program" also calls for the publicity of the accounts of all corporations operating under municipal franchises.

The "Municipal Program," as we have stated in previous issues, is an admirable model for a city or town charter. The particular features just cited are directly in line with legislation enacted or proposed in several States, as already noted in the first part of this article.

Finally, great injustice would be done if the American Statistical Association were left unmentioned. Many papers on municipal statistics have been read and discussed before that body, and it has given particular attention to improvements in vital statistics.

Criticisms and a general discussion of the work of the various State officials and voluntary organizations noticed in the foregoing review will be found in our editorial pages.

*One of Mr. Cahoon's chief objects in submitting the paper and schedules was to stem the tide in favor of municipal ownership and reduction in rates for lighting service. See Eng. News, June 14, 1900, for abstract bringing out these points.

†"First Annual Report of the Committee on Technical Investigation," National Brick Manufacturers' Association, 1899.

## REPORT OF COMMITTEE ON COMPOUND LOCOMOTIVES.*

The great source of waste in the use of steam in a single cylinder is the alternate heating action of the entering steam and the cooling effect of expansion and condensation on its walls and the consequent wasteful condensation and re-evaporation of steam. Any expedient which will reduce this waste by preventing the transfer of heat from the steam to the exhaust side of the cylinder without transformation in proper proportion into work, will reduce this loss and increase the efficiency of the machine.

This is effected in compound locomotives by a limited expansion, submitting as far as may be necessary to cylinder condensation and re-evaporation, but then transferring the working steam, both the condensation and the re-evaporation, to a second cylinder, in which the latter portion may either do some work or balance its waste more or less fully.

The question of adoption of the compound engine for the usual work of the locomotive where speed, pressure or load, either or all, is expected to be variable, is complicated by the fact that it is impracticable to find cylinder proportions which will be permanently suitable. Notwithstanding this difficult feature in design, the demand for larger engines and the thin partition which divides a net profit from a loss in railway operation render it well-nigh imperative that a solution be found for this perplexing problem. The heavier a locomotive, the smaller is the relative boiler capacity that can be supplied.

The limit in steam production once reached, the required gain in power can be attained only by a more

*Abstract of a report presented by a committee of the American Railway Master Mechanics' Association convention in June: J. F. Deems, A. E. Mitchell, John Player, J. E. Sague, J. H. Setchel.

economical use of the steam generated, and if the compound has the advantage claimed by its advocates, it seems that it will of necessity be adopted. The advantages accruing from compounding may be summarized as follows:

1. Reduction of expansion in one cylinder and consequent reduction of internal waste.
2. Ability to adopt large ratios of expansion with light loads without wire drawing.
3. Reduced leakage in engine.
4. Reduction of depreciation of boiler.
5. Greater boiler efficiency.
6. Lighter blast, smoother draft, less waste, annoyance and danger from sparks ejected from locomotives.
7. Elevated limit of speed and power.
8. Reduced loss by tender and fuel haulage.
9. Greater uniformity of crank movements.
10. Larger efficiency of machine.

To offset these gains, there are losses which may be enumerated as follows:

1. Increased first cost.
2. Increased cost for repairs and maintenance of machinery due to multiplicity of parts and greater weight of reciprocating parts.

As different men working out the same problem will develop it on different lines, so has the compound locomotives taken different forms, which may be classified as follows:

(1) Two-cylinder receiver, without separate exhaust for high-pressure cylinder and automatic starting gear: (A) With intercepting valve: Von Borries (early), Worsdell, Schenectady (early Pitkin), Dean, Baldwin (early), Brooks (Player), Rogers. (B) Without intercepting valve: Lindner, Golsdorf, Cook (early).

(2) Two-cylinder receiver, with separate exhaust for high-pressure cylinder; optional starting gear with intercepting valve: Mallet, Schenectady (new), Richmond (Meilen), Rhode Island (Batchellor), Pittsburgh (Colvin), Von Borries (latest), Baldwin (latest), Cook (latest), Rogers (latest).

(3) Four-cylinder tandem compound, two crank, no receiver: Dunbar (Boston & Albany), DuBousquet (Woolf), Baldwin (Vauclain), Johnstone.

Four-cylinder tandem, two crank, receivers: Hungarian State, S. W. Russian (Mallett), Brooks.

Three-cylinder, three cranks: Webb (L. & N. W. Ry.), Northern Railway of France.

The growth in numbers and the interrupted progress is seen in the table showing the total number of all types turned out each by the builders in the United States. These figures do not include the compounds built by different railroads for which the different locomotive works might or might not have furnished cylinders.

| | | | |
|---|---|---|---|
| 1889 | 2 | 1895 | 73 |
| 1890 | 9 | 1896 | 195 |
| 1891 | 100 | 1897 | 142 |
| 1892 | 263 | 1898 | 348 |
| 1893 | 237 | 1899 | 371 |
| 1894 | 38 | | |
| | | Total | 1,778 |

In order that the committee might arrive at some definite conclusion as to the position which the compound locomotive occupies at the present time, about 730 circulars of inquiry were sent out, but 30 answers were received. As many roads have had no experience with compounds, this is perhaps not surprising.

Two roads report that there is no appreciable saving by the use of the compound. Twelve report a saving varying from 8.9 to 30% with an average of 16.0%. The economy is based, usually, on the ton-mile system, and where the car-mile is used as a basis, two empties are equal to one load. For switching service there is only one favorable report.

For two-cylinder compounds in freight service the minimum ratio is 1 to 1.5; the maximum, four out of eight prefer 1 to 2.5. The average is 1 to 2.328. For passenger service the maximum is 1 to 2.5; the minimum is 1 to 2.125; average, 1 to 2.375. In the four-cylinder compounds, the preference is about 1 to 3, a variation being permitted so that the dameters of the cylinders may be conveniently measured.

The automatic is preferred in three cases, as its use eliminates the chance for abuse by the engineer. Eight prefer manual control of the compounding feature, as by this method the engines start better and are stronger and are more flexible as regards power, thus enabling an engineer to help a heavier train over a ruling grade or prevent stalling under adverse conditions. Two prefer to use the automatic feature in starting, but yet give the engineer power to use the engine simple when emergency demands it.

In one case no merit is found in relieving cylinders while drifting and in another the by-pass is not satisfactory. Of the remainder, those using four-cylinder compounds relieve the cylinders by means of relief valves, and those using the two-cylinder type use the by-pass. Slightly opening the throttle is also resorted to in a number of cases.

Seven report that they are using the piston valve. Three report that they use the slide valve. Five report using both types, but that the piston valve seems to give more satisfactory service as regards strain on the valve motion and wear of valve seats. On one road it was found the slide valve gives the least trouble. In some cases there have been broken eccentric rods and they have been in all cases on engines of the piston-valve type.

Eleven roads report that the compound is not out of service more than the simple and six report that it is out of service more than the simple. The parts needed for repairs on a compound are often not at hand, as they differ from the standard of the road. In this way time is often lost. On one road it was found necessary to close the guides more often on the compound. As to the boilers, four roads find no difference in the cost of boiler repairs, seven think they are less, and five give the percentage saved as varying from 10% in one case to 28% in another, the average being 19.6%. Five find no difference in cost of maintenance of machinery; six state that compounds cost less in this respect, and four give the increase at from 11% to 50%, the average being about 25% more. Five find no difference in cost of lubrication; three find that the compound costs less; two state they cost more and five that the compound costs from 10% to 25% more than the simple engine, the average being 18%.

Ten replies state that the compound is always economical and can be so used whatever the cost of coal, one stating that with the compound a cheaper fuel can be used and another that the compound, while always showing a saving in per cent. of fuel saved, it could be used to the best advantage where the cost of fuel is high. It might be of interest to compare the number of compound locomotives, the percentage of the equipment which they constitute, and the cost of fuel. In a general way it may be stated that where coal is most expensive, there the compound is in greatest favor, as shown by the above figures. However, the personal element of progressiveness enters so strongly into the question that the figures may have little actual comparative value.

| Cost of fuel per ton. | No. of compounds. | Equipment. | Cost of fuel per ton. | No. of compounds. | Equipment. |
|---|---|---|---|---|---|
| $0.70 | 58 | 14.00% | $1.85 | 66 | 7.80% |
| .75 | 25 | 7.68% | 1.85 | 4 | .59% |
| .80 | 39 | 5.30% | 2.00 | 6 | 3.80% |
| 1.05 | 47 | 20.00% | 2.22 | 31 | 32.00% |
| 1.38 | 84 | 9.00% | 2.25 | 2 | 15.40% |
| 1.50 | 13 | 3.12% | 2.40 | 1 | .52% |
| 1.65 | 97 | 17.20% | 2.70 | 140 | 46.00% |
| | | | 3.00 | 22 | 8.90% |

In nine cases, no difference in size of the nozzle is made, and in five the difference is in favor of the compound. In one or two instances the nozzle of the compound was reduced in diameter to improve steaming of engines.

Nine of the replies indicate that it is practicable to build compounds of similar size and power to the largest simple engines which have been recently built. Two think it is not possible.

Improvements in those parts directly connected with the compound feature are improved construction of the intercepting valve and the use of an over-pass valve which relieves the low-pressure piston, when drifting, improved cylinder ratios, the use of the piston valve, the use of the two-ported slide valves, and the manual control of the compound feature, either in starting and emergency or in emergency alone.

Improvements necessitated by the introduction of compounding include stronger cross-heads and piston rods, larger bearing surface on cross-heads, wider guides and better frames.

Improvements in assignment consist in the use of compounds on through trains where there is little switching to do, their use on level roads where there is little occasion to drift, and their assignment to high-speed passenger trains because of their ability to work regularly and easily in such service and to pick up readily the time lost on account of detentions.

There is a need of improvement in the intercepting valve and a change in design, so that the same pressure will be exerted by both pistons; the necessty of reducing the back pressure at high speeds is also apparent. Frames seem too weak, and where the single-rail frame is used there is difficulty in holding the cylinder and frame together. The cross-head, piston and valve-rod packing and relief valves all show the need of proper attention and consequent improvement.

Definite and accurate data as to the saving effected by compounding and the cost of repairs was rather difficult to obtain, which is to be regretted, as it would undoubtedly aid in deciding the minimum cost of coal with which it would be economical to use the compound. However, such data as could be obtained relative to the above points are here presented in tabulated form. In the cases cited, comparison was made between engines of similar size and type and engaged in the same service, as far as possible, differing only in the matter of compounding.

| Name of road. | Cost of repairs per engine mile—Compound. | Cost of repairs per engine mile—Simple. | Saved in fuel due to compound'g. |
|---|---|---|---|
| C. & L. | 0.0909 | 0.0537 | 25.00% |
| Chic., Burl. & Quincy | .0168 | .0125 | 16.69% |
| Erie | .0407 | .0294 | ..... |
| M., St. P. & S. Ste. M. | .0001 | .0729 | 9.60% |
| Northern Pacific | .0179 | .0209 | 20.00% |
| Average | 0.0393 | 0.0379 | 17.62% |
| In Passenger Service. | | | |
| Chic., Burl. & Quincy | 0.0241 | 0.0190 | 13.80% |

From an inspection of the figures here given it would seem that in the matter of repairs the advantage is with the simple engine, while the compounds without exception have the advantage in fuel economy. The data obtained are quite too meager to permit drawing any definite conclusion as to what average result might be expected from the compound under any given set of conditions.

## Discussion.

Mr. S. M. Vauclain (Baldwin Locomotive Works): The first time I had the honor of addressing this association on compound locomotives was at Cape May in 1891. At that time, there were seven prophecies made in regard to the future of compound locomotives, the American type of engine and the Wootten firebox. I think that the prophecy which I made at that time concerning the compound locomotive has been fairly well borne out by what has been done during the past nine or ten years.

The committee states that the compound engine is still in the experimental stage, but when we consider the state of the art in this country I think that no one can take exception to changing the first conclusion to read something as follows: "Compound locomotives have not been generally adopted by railroads in America but are coming rapidly into use for both freight and passenger service." We have turned out for the first six months of this year 600 locomotives, and it is fair to presume that the remaining six months will see us with 1,200 engines to our credit at the end of the year. Of this number from 300 to 400 will be foreign locomotives, and 800 will be domestic locomotives. Of the latter number some 500 will be compound. This is definite, because the locomotives are practically ordered.

I have taken the position that the experimental stage in compound locomotives was passed long ago. It certainly was passed long ago not only on the four-cylinder engine which I have to stand for, but for the two-cylinder compounds locomotives as well. There are various types of two-cylinder compounds and all are giving good satisfaction. We see two-cylinder compounds and four-cylinder compounds being changed slightly from time to time in the matter of simple improvements; but show me the simple engine to-day that is not being constantly improved? Do we build our simple engines to-day as we built them ten years ago? What railroad in the United States would equip its road to-day with locomotives such as were built ten years ago of simple engines? It would be the utmost folly. Therefore, is it not reasonable to expect as we progress in the building of compound locomotives we are going to add improvements from year to year in their construction? If we are doing this, it does not follow that such improvement in the design in the locomotives can be attributed to the fact that these locomotives are simply emerging from the experimental stage. If we take that view of affairs, we are going to be in the experimental stage with compound locomotives all our lives.

The report says that compounds have been in use in freight service longer than passenger service and there are more in such service, but in recent years there seems to be a disposition to use them also for fast heavy passenger service. The compound is not as well adapted to switching service as the simple engine. As to the first line of this conclusion, that "compounds have been in use in freight service longer than passenger service," I beg to say that the first compound locomotive that was built in this country by the Baldwin Locomotive Works and about the first put in service outside of experimental types in England, was a compound passenger locomotive for the B. & O. R. R. The reason that more compound locomotives are used in freight service is simple, because there is more freight to haul than passengers and we must have more compounds in freight service than in passenger service.

On many of the railroads for which we built compound locomotives, the freight power and the passenger power are both compounds, and on the same principle. We, of course, meet with a peculiar state of affairs. We go to a railroad which will not have compound locomotives for freight service. They are all right for passenger service, but will not do for freight service. Then we meet with the reverse conditions—they are all right for freight service but no use for passenger service. If these two opposing parties were to exchange ideas to any great length, I am inclined to believe they would use them for both freight and passenger service.

Mr. Dean.—It is very gratifying to see such a unanimity of opinion in favor of compound locomotives. I think it will be interesting if we can hear from some other people who do not use compound locomotives, and we would like to know their reasons for not using them. It is well known that there are many roads on which there are practically no compound locomotives, and on which there are not likely to be any very soon.

Mr. A. M. Waitt (N. Y. C. R. R.).—I do not know that I have any special reason to state why the New York Central is not using compound locomotives, except that the past experience which the road had, was such that they had a number of compounds and changed them over to simple engines. They also had some compound switchers which were not found entirely satisfactory. The state of the art in compound engines seems to be progressing rapidly, and improvements are being made.

I am sure from the report of the committee and the discussion to-day I have personally received a great deal of light, and have a very strong temptation to give consideration to the compound locomotive such as I have not given it before. There are, however, so many types that are presented that I do not know what the outcome will be.

Mr. G. L. Fowler.—In regard to the point that manual control of the compounding feature is preferable to the automatic, my observation goes to show that the automatic would be preferable rather than the manual, on the ground that the automatic feature changes the engine into a compound immediately as the engine starts, but if it is allowed to work as a simple engine in starting, the engineer will work it as a simple engine longer than is necessary, with the result that there is a greater consumption of steam, especially if it is allowed to run any length of time in that condition, unless the manual control be of such a nature that when the speed of six or seven miles an hour be reached the consumption of steam is so great that the engine cannot run any faster, or the exhaust be so throttled the engine cannot get rid of the steam. In that case the engineer is obliged to close the throttle and allow the engine to go into compound.

Mr. Sague.—In regard to the attitude of some of the builders of compound locomotives, I would say for the Schenectady Locomotive Works that we favor the compound engine very thoroughly. We have had very flattering reports from most of the compounds we have built during the last six or seven years. We consider the compound engine thoroughly out of the experimental stage. We expect to improve the details from day to day. We think that in ten years from now our compound engine will be materially different from what it is to-day. Some of the objections raised to compound locomotives at the beginning of their use in this country are interesting reading to-day. It was objected to the two-cylinder compound that the low-pressure cylinder would be ungainly for heavy locomotives. The limiting clearances in the case of two-cylinder compounds are the clearances of the cab or the clearances relating to the main crank-pin.

The weight of the reciprocating parts has not been touched on in this discussion. It is an impossibility to make reciprocating parts as light in a compound locomotive as in a single locomotive. We have urged for years in this convention that reciprocating parts should be reduced to the minimum, and a number of builders have done all they could and strained a point, possibly to make the pistons light, the cross-heads light, and the piston rods light, for the purpose of diminishing the reciprocating counter-balance on the track. And that has been lost sight of somewhat in compound locomotives on passenger service. We would like to have a locomotive in which the dynamic effect on the track is a certain amount, not to exceed a load of 30,000 lbs. on the driving wheels at 60 miles an hour. In order to do that we have to lighten the weight of the reciprocating parts. We are called upon to balance the locomotive so that it will ride easily. I have only known of two cases in my experience in which the railway has analyzed the effect of the reciprocating parts on the track.

Mr. G. W. Rhodes (B. & Mo. R. R.).—I am interested to see how pleasantly we all assume the responsibility for the large and growing increase of the use of compound locomotives. I was fearing all the time that some supply man would say that we were robbing him of what was his due, and that it was his commercial methods with the vice-presidents and higher officials of our roads that were largely responsible for the introduction of these engines.

## EXPLOSIONS AND IGNITIONS IN AIR COMPRESSORS AND RECEIVERS.*

By Alfred George White, M. Inst. C. E.

The attention of engineers in this and other countries has from time to time been drawn to the results of explosions which have occurred in air compressors and receivers. In some cases the cause has been ascertained, but, as far as the author is aware, no systematic investigation of the subject has been made with a view of obviating the disastrous results of explosions and ignitions, which the author believes to be more frequent than is generally known. The following account of a recent occurrence of this nature which came under the author's notice, with a description of the compressor, may help to throw light upon the subject.

The air compressor was employed for the purpose of supplying air to rick drills and hoisting engines in a copper mine in Norway. The usual working pressure being between 50 lbs. and 60 lbs., the safety-vale of the receiver was loaded to blow off at the latter pressure. It had been continuously at work for 17 years and was of English make, with two horizontal air cylinders, 24 ins. in diameter and 36-in. stroke. The motive power was supplied by a high-speed turbine on a horizontal shaft, upon which a pinion was keyed, gearing with a spur wheel on the compressor driving shaft. On this shaft also there were keyed a heavy flywheel and two crank-disks, which worked the air-cylinder pistons by means of connecting rods in the usual way. The inlet valves were plain circular valves with stems, four being placed in each cover of the air cylinders. Bell crank levers fitted with counterweights were attached to the valve stems for closing the valves at the end of each stroke before compression commenced, the atmospheric pressure opening them simultaneously during the inward or inspiration stroke. The outlet valves were of the ball type, of solid brass, fitted in brass seats, two on each delivery port on the top of the cylinders, their action being regulated by the pressure of air in the cylinders and receiver.

The cooling arrangements consisted of an open water jacket around each cylinder, the water supply being admitted near the surface on one side and discharged through an overflow pipe, of ¾-in. bore, on the other side at the same level. The water surrounded the cylinders and air-delivery ports, and stood about 1 in. deep over the latter. The water supply and discharge being placed at the same level near the top, the water simply flowed over the surface, and did not circulate round the cylinder. It will thus be seen how imperfect the cooling action was in this instance.

The oil used in lubricating the air cylinders was composed of crude fish oil and tallow mixed together, and was put into the cylinders through the inlet valves by a common oil can. The lubrication, therefore, depended entirely on the attention and skill of the attendant, and no doubt at times a greater or less quantity of oil was poured into the cylinders than was required, and any surplus was driven out through the delivery valves into the air pipes and receiver.

The air receiver, placed inside the compressor house, consisted of a wrought-iron cylinder about 20 ft. long by 4 ft. 6 ins. in diameter, and was connected to the air cylinders by an 8-in. cast-iron pipe. This pipe had an ordinary spigot and socket joint on the horizontal portion between the receiver and compressor. The joint was made of lead run in and caiked, but owing to the contraction and expansion of the pipe it leaked, and had to be renewed from time to time. On the day of the ignition, and shortly before its occurrence, this joint had been renewed by running in molten lead against a hempen gasket, and very soon after the compressor was started flames suddenly blew out in great volume from the safety vale on the air receiver. The attendant succeeded in stopping the compressor within a few moments, but the flames continued for some time and set fire to the compressor house, which was built of timber, and in the course of half an hour it was burnt to the ground.

The author considers the cause which led to the fire breaking out in the receiver to have been the ignition of the oil accumulated there, and the use of molten lead in making the spigot joint of the pipe referred to, by which the oil must have been first ignited in the pipe. On starting the compressor, the draft of air created would cause the ignited oil in the pipe to set fire to the oil in the receiver, or the fire may have already spread to the receiver. The products of the decomposition of the large quantity of oil in the receiver would, in conjunction with the air, form an explosive mixture, which, failing relief through the safety valve, might have resulted in an explosion. The cause of all explosions and ignitions of this nature can be traced to these phenomena. The case which occurred at the Westphalia Colliery in 1896 resulted in destruction of the air receiver by bursting. In the present instance the rise of pressure does not appear to have been sudden enough to burst the receiver, and the relief afforded by the safety valve averted this catastrophe. When the receiver was opened it was found to contain a quantity of charred oil in the form of a sticky paste about 2 ins. deep in the bottom. The air pipes were coated inside with a similar substance. The damage done to the compressor and receiver was, however, considerable, the riveted joints of the latter being started and the lead joints of the contiguous pipes and connections melted out. One cylinder of the compressor and one crank disk were cracked, as also were two arms of the turbine, which was placed inside the house burnt down. The latter effects were chiefly due to the subsequent fire and the water which was thrown upon the heated metal.

The primary cause of this fire was the accidental ignition of the oil by the admission of molten lead into the pipe referred to, but the same effect may be produced by an increase of air pressure, and consequently of temperature, to a point at which the decomposition of the oil and ignition of the air and gas mixture take place, or by the admission of coal dust or inflammable matter into the valves or cylinders of the compressor. The use of oils possessing low-flashing temperatures, and the increase of temperature from friction of metallic surfaces improperly lubricated, are also elements of danger, besides defective water-jacketing and cooling arrangements.

The temperature of air when compressed adiabatically to 58.8 lbs. per sq. in. gage pressure from 60° F. initial temperature is 270° F. The air admitted to a compressor is, however, sometimes at a much higher temperature than 60° F., and may in some instances be as high as 100° F.; the temperature of this air when compressed to 58.8 lbs. per sq. in. gage pressure will rise to about 430° F., and when compressed to 75 lbs. per sq. in. the final temperature is nearly 500° F. This shows the importance of, (1) a low initial air temperature; (2) adequate cooling of the air before or during compression; and (3) the use lubricating oils of high flashing and ignition points.

A similar ignition to the one mentioned by the auth occurred in 1897 in the Clifton Colliery air receiver, a tests were made of the oil then in use, giving the follow results:*

| | Flashing point. Close test. | Ignition poi |
|---|---|---|
| Sample No. 1..... | 454°F. | 594°F. |
| " No. 2..... | 460°F. | 588°F. |

Lubricating oils of high-class manufacture, distilled fr petroleum and used for high-pressure steam engines, g flashing points of 530° F. to 560° F. (open test), and ig tion points of 600° F. and 630° F. It is, however, son times the case that oils having a high flashing point a mixed with others having a much lower one, and therefo a guarantee should be demanded or a test of the oil shou be made. The flashing point of the oil used in the com pressor described by the author, taking that of Arct sperm, would be only 446° F.

It is evident that, given reliable oil of high flashin point and normal conditions of working for a well-designe air compressor, the danger of ignition is practically elim nated, as shown by the following table:

| | | | |
|---|---|---|---|
| Working pressure, air, lbs.pr sq.in. | 58.8 | 58.8 | 75 |
| Initial temp. of air, °F..... | 60 | 100 | 100 |
| Final temperature of air,† °F..... | 370 | 435 | 500 |
| High temperature oil: | | | |
| At flashing point, °F..... | 530 | 560 | |
| At ignition point, °F..... | 600 | 630 | |

†Compressed adiabatically.

The final temperature of the air will of course be diminished when the air is cooled during compression, in proportion to the efficiency of the cooling apparatus, and in hot countries, where the initial temperature of the air is high, the addition of an apparatus for cooling the air prior to admission to the compressor, in addition to other cooling arrangements, would be attended with economical and advantageous results.

With reference to the design of air compressors, the author is of opinion that the following points require special attention: (1) The arrangement of the air admission to the compressor in such a manner that the lowest possible initial temperature is obtained, and the air protected from all dust or inflammable matter and sparks. (2) Efficient water-jacketing of the air cylinders by closed jackets, with water supply under pressure, and, in the case of double-stage compressors, an intermediate cooler of adequate capacity. (3) The more general adoption of compound or double-stage compressors with intermediate coolers, whereby a more effective cooling of the air and greater economy of power are attained. (4) The employment of automatic lubricators on the air cylinders. (5) The use of pyrometers, whereby the temperature of the air in each cylinder and in the receiver can be seen by the attendant. (6) The reduction of clearance at the ends of the cylinders and of the valve ports to a minimum. (6a) The design of valves having definite action, without friction in working, of ample area and readily removable for inspection or cleaning. (7) The use of tested oils having high flashing points. (8) Proper arrangements for draining and blowing off accumulated oil in both air receiver and pipes.

About two years previous to the ignition described by the author, an explosion occurred in one of the cylinders of the same compressor, resulting in destruction of the cylinder. The cause of this was not ascertained at the time, but it was probably due either to excessive friction in the cylinder or defective action of the valves, causing an increase of temperature and consequent decomposition of the oil, or to an increase in the air pressure sufficient to burst the cylinder.

The production of fire by means of the sudden compression of air is known to the aborigines of the Philippine Islands, who employ a small tube fitted with a plunger, which, on being sharply struck, ignites combustible matter placed at the bottom of the tube.

*Abstract of a paper read before the Institution of Civil Engineers of Great Britain.

*Transactions of the Federated Institution of Mining Engineers, Vol. xiv., Part 4.

EXPORTS OF COAL FROM THE UNITED STATES, says the U. S. Bureau of Statistics, were nearly 50% greater in the ten months ending with April, 1900, than in the same months of the preceding fiscal year, and 80% larger than in the corresponding months of 1898. This is partly explained by the fact that in 1898 our total coal production, for the first time in our history, was larger than that of any other country. In 1896 the total coal product of the world was 664,000,000 short tons; though this total was only 202,000,000 metric tons in 1878. As to the relative production of England, Germany and the United States in the last 30 years, in 1868 England produced over three times as much as either Germany or the United States; the output of these countries being relatively 32, 14½ and 16½% of the world's production. In 1875 the relation stood at 45, 20 and 18% of the total; in 1880, it was 36, 28 and 17%; in 1896 it was 34, 30 and 19%; and in 1897 England's output was 226.4 million net tons; the United States, 200.2 millions tons, and Germany, 132.7 million tons. In the period 1868-97, the English output was increased 96.4%; that of Germany, 266.1%; while the coal production of the United States gained 532.3%.

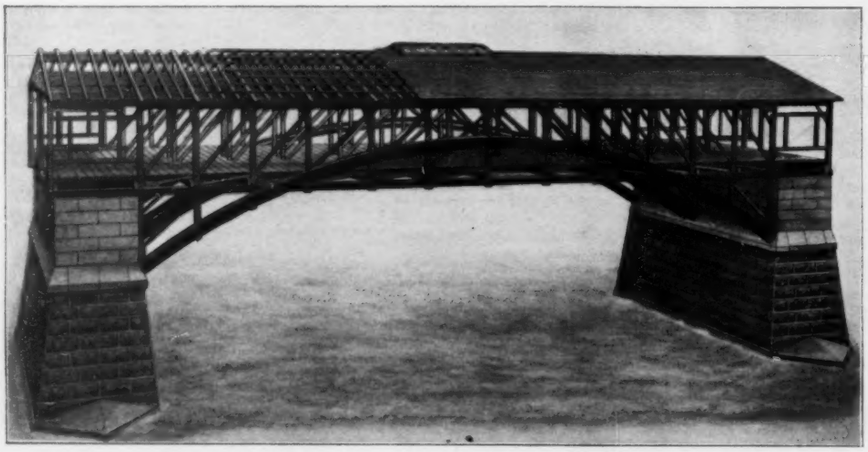


FIG. 1.—WOODEN RAILWAY BRIDGE OVER THE SCHUYLKILL RIVER IN PENNSYLVANIA, BUILT IN 1832.

FIG. 4.—TYPICAL PIN-CONNECTED THR

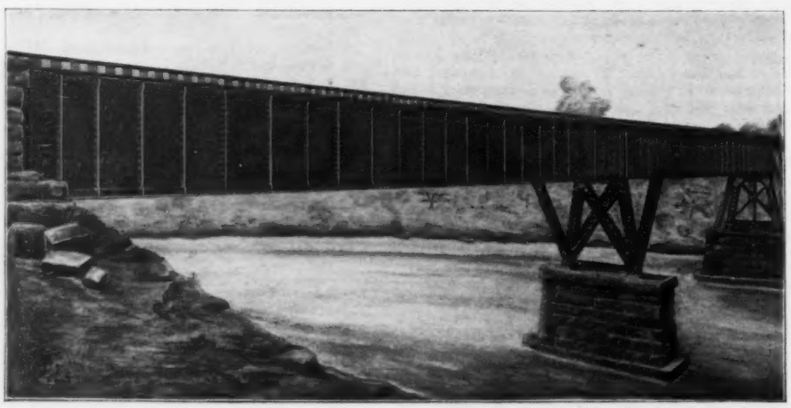


FIG. 5.—TYPICAL PLATE GIRDER DECK BRIDGE.

FIG. 2.—TYPICAL RIVETED THROUGH T

FIG. 6.—GRAND TRUNK RY. SUSPENSION BRIDGE OVER THE NIAGARA RIVER, BUILT IN 1853.

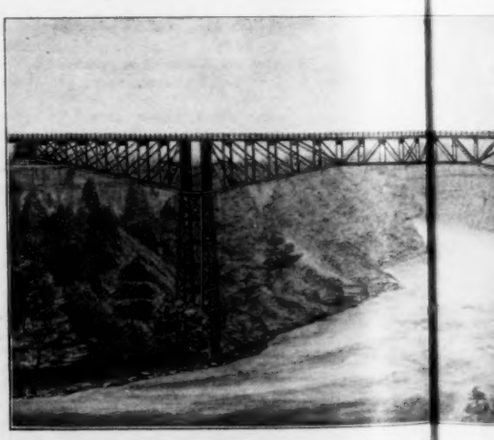


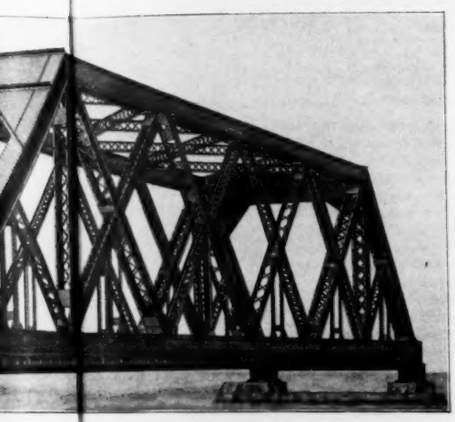
FIG. 8.—MICHIGAN CENTRAL RY. CANTILEVER BRIDGE O
1884.

FIG. 10.—SWING BRIDGE OVER THE MISSISSIPPI RIVER AT ROCK ISLAND, ILL.

TYPICAL AMERICAN RAILW
AT THE PARIS EXPO

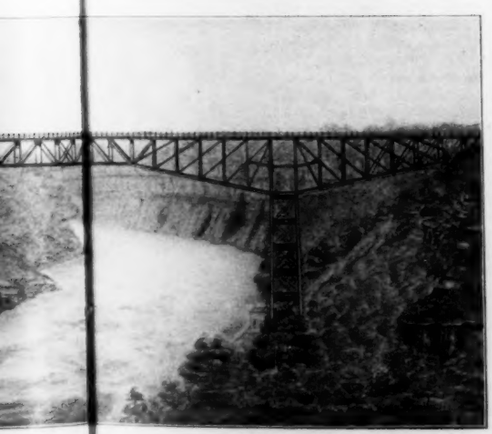
-CONNECTED THROUGH TRUSS BRIDGE.

FIG. 3.—END VIEW OF RIVETED THROUGH TRUSS BRIDGE.



IVETED THROUGH TRUSS BRIDGE.

FIG. 7.—THE EADS BRIDGE, ACROSS THE MISSISSIPPI RIVER AT ST. LOUIS, BUILT IN 1874.



NTILEVER BRIDGE OVER THE NIAGARA RIVER, BUILT IN 1884.

MERICAN RAILWAY BRIDGES
HE PARIS EXPOSITION.

FIG. 9.—GRAND TRUNK RY. ARCH BRIDGE OVER THE NIAGARA RIVER, BUILT IN 1897.